TELESCOPE MAKING 34

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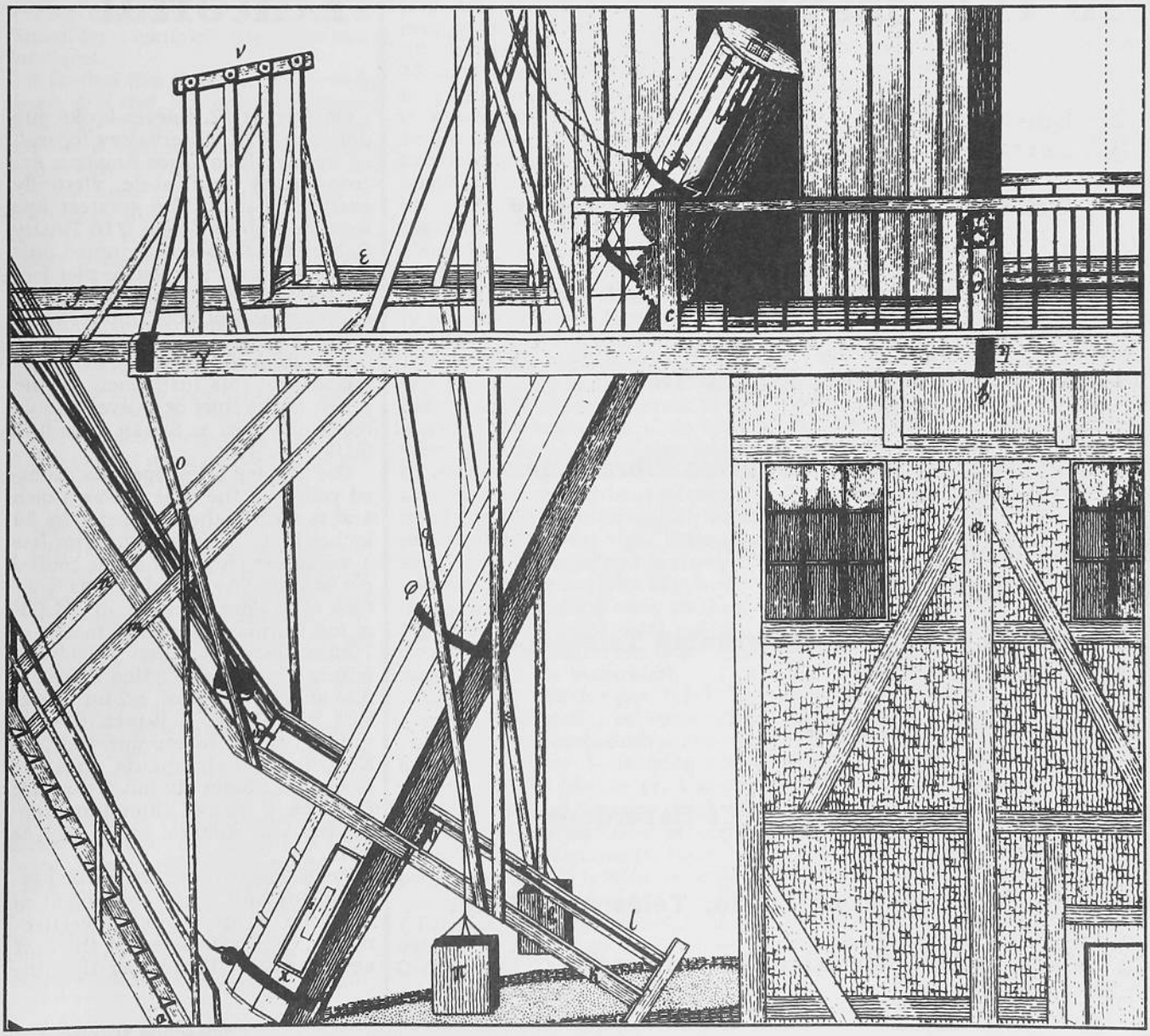

Telescope Making #34

The magazine *for*, *by*, and *about* telescope makers!

Editor: Richard Berry
Associate Editor: Robert E. Cox
Managing Editor: Stephen Cole

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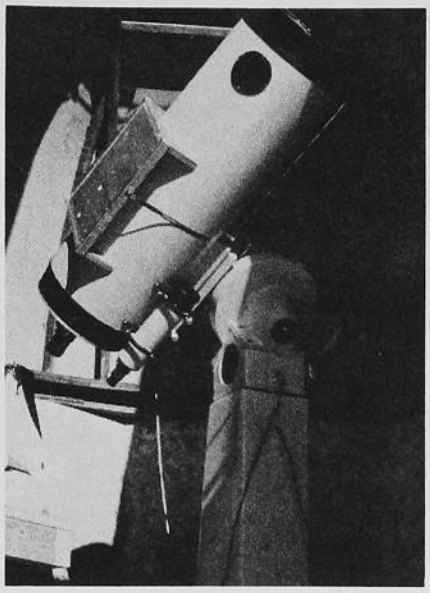
Editorial

On August 17, thieves broke into Johnson-Weil Observatory (operated by the Albany Area Amateur Astronomers) and stole virtually everything in it. The greatest loss was the club's 12-inch f/16 Tinsley Cassegrain telescope mounted on a massive observatory-style pier (see photo). Club members put an enormous amount of work into restoring this telescope. Anyone having any information that could lead to the recovery of this instrument or the arrest of the thief or thieves should telephone Alan or Susan French at (518) 374-8460.

The Tinsley telescope was painted yellow at the time it was stolen and is 12.5 inches diameter by 44 inches long. The primary mirror has a distinctive chip next to the central perforation. Also stolen was a 6-inch f/10 Newtonian on an old Edmund German equatorial mount, a 70mm finder for the Tinsley, a 55mm University Optics Plössl, a 32mm TeleVue Plössl, a 24mm TeleVue Wide-Field, a 2-inch off-axis guider with telecompresser, a Northeast Instruments sidereal clock, a 12.5mm illuminated-reticle eyepiece, a 16-foot aluminum step-ladder, star atlases, tools, and so forth.

Please keep an eye out for this instrument and other equipment at amateur swap meets, advertisements, or private sales for the next several years. Remember that the



telescope may be repainted or otherwise modified. Contact Alan or Susan for a complete list of the stolen items.

A theft of this type makes me very angry and sad. Not only is it devastating for the telescope makers and amateur astronomers who lost equipment lovingly restored but also because the popularization of astronomy will be set back. As word of it gets around, I am sure that many clubs will think twice before inviting the general public to enjoy the skies from their observatories. The Albany Area Amateur Astronomers were very active in their public programs—if this is their reward, will other clubs dare to be so open? It hurts everyone. I therefore appeal to the perpetrator(s) of this crime—if you care at all about astronomy—to return what you have stolen.

Now to regular business.

The number of astronomical meetings held each year has really grown—so far this summer I've been to four—and Astrofest will make five. Between the Astronomical League, the Baltimore meeting of the International Astronomical Union and IAU Colloquium 112 on Light Pollution, Radio Interference, and Space Debris, I missed the mecca of telescope meetings, Stellafane. And earlier this year, as time pressed tight, I had to choose between Riverside and the TSP, and, as a telescope maker, selected Riverside.

But all was not lost—Dave Eicher attended both TSP and Stellafane for **Deep Sky** and offered to cover both meetings for me. Dave is primarily a telescope user, but he's got a sharp eye for new telescope designs, shoots lots of pictures, and asks lots of questions. Thanks Dave, for your coverage of these two important meetings—I'll write an article for **Deep Sky** in plenty of time for your next deadline!

However, I *did* make the ALCON 88 meeting in Council Bluffs and, though I was really there primarily for ASTRONOMY, did see some interesting telescope and observatory design. I'll report on the ALCON meeting in *TM#35*, along with a report on the midwest's own Astrofest, scheduled for the same weekend this issue of *TM* goes to the printer. I'm hoping for good weather and clear skies—a 50-50 proposition at his time of year.

During the IAU Colloquium 112 in Washington, I had a chance to look through the 12-inch and 26-inch refractors at the U.S. Naval Observatory. Despite the incredibly thick, muggy air (or perhaps *because* of it!), the view of Saturn through the 12-inch Saegmuller refractor was magnificent—perhaps the finest view I've ever had. (*TM* ran Ted Rafferty's story of this telescope's restoration in issue #15.) And the 26-inch? It did a fine job with Uranus. An aside: These telescopes are impressively well mounted for visual observing. I really shoved on the tailpiece of the 26-inch and couldn't even get 1 arcminute of wobble. Every amateur's dream telescope ought to be placed on such a solid mount.

This, in an oblique sort of way, brings me to my main point. I've noticed a lot of reader interest in restoring older telescopes to their full glory. But because it's possible to harm an antique with a misguided restoration, would-be restorerers need accurate information and practical hands-on tips. (Besides, even if you never intend to restore a telescope, there are a lot of valuable design ideas tucked away in them. My 6-inch f/8 equatorial reflector described in *Build Your Own Telescope*, owes its inspiration to Ken Launie's old reflector (see *TM#13*)).

If you personally, or your club, college, or planetarium have restored an older telescope, *TM*'s readers would like to read about what you did and how you did it. Or, if you have professional expertise in restoring old instruments, there are people need your advice. In either case, please drop me a line.

The next issue of *Telescope Making—TM#35*—goes to the printer on December 21. Until then...

—Richard Berry

Letters

Watch Out for the Caustic!

Dear Richard/ I have received a lot of favorable mail and phone calls about my article on testing paraboloids (*TM#33*). I'm a little embarrassed by it, in fact. Most people who contact me seem to be almost painfully grateful. I have the feeling that if I met them in person, tears would well in their eyes and they would say, "Bless you, kind sir!"

Some explanation of my use of the word "parabola" versus "paraboloid" needs to be made, because I am sure that some people out there have already noticed my seemingly sloppy or inattentive use of these words. There is a method to my madness. Whenever I am referring to a cross-sectional measurement or theoretical quantity (a line across the mirror is what the zones approximately cover), I use the more precise term "parabola." Whenever I talk about the surface as a whole, I refer to it as a paraboloid.

One error I didn't catch when I wrote the WAVE INFLATION box was that I meant error at the FOCUS of the 70 percent zone, rather than at the center of curvature. This is a subtlety: I'm sure everyone knew what I was talking about.

I got some interesting correspondence concerning one of my statements. I mentioned how it seemed that the zone-masked Foucault test had a systematic error. Irv Schroader wrote me that this systematic error is well known (see "The Caustic Test" by Irvin H. Schroader, *Amateur Telescope Making Book Three*, (Scientific American, 1953), page 429). It is caused by the finite width of the zones and the fact that the center of curvatures are on an off-axis line known as the caustic (see figure). Of course he is right, and I thought I had discovered a deep, dark secret of the Foucault test!

The problem is that this systematic error probably varies from user to user, so it can't be universally calibrated like "add 20 percent to the correction of an f/4 mirror," although it is likely to be measured consistently by a single user. Individuals, if they tested enough mirrors, could probably come up with a personal equation versus f/ratio for correcting mask data, as long as

continued on page 38

Building a "Two-Weekend" Observatory

When I moved from a light-polluted site in the city of Milwaukee to the countryside thirty-five miles north of the city, I began thinking seriously of building an observatory to house my 20-inch reflector (see *TM#7*).

My previous observatories had been roll-off roof buildings (see *TM#11*). Because my new site is near the shore of Lake Michigan and is almost always windy and because the first winter's observing convinced me that if I had once been able to stand near-zero cold with a stiff wind from the northwest, that time was past history, I wanted a new building to provide better wind shelter than roll-off buildings do.

Last summer I checked the land for locations with a good horizon but a sufficient number of trees to block the lights of farmhouses. I identified two sites: one near a little pond about 300 feet from the house (the "prime site") and the second 100 feet from the house, naturally sheltered between two rows of cedar trees (the "back-up site"). Luckily, because the former owner had worked for the electric company, the prime site already had electric power (220-volt 3-phase power, no less!) and roughly a half acre of level, usable ground. The back-up site was a convenient distance from the house, smaller but not level, and suffered from 10-degree horizon obstructions to the east and west.

In the end I decided to postpone the big observatory and build a test observatory first. Using the 20-inch on the concrete slab in front of my garage showed that I needed a

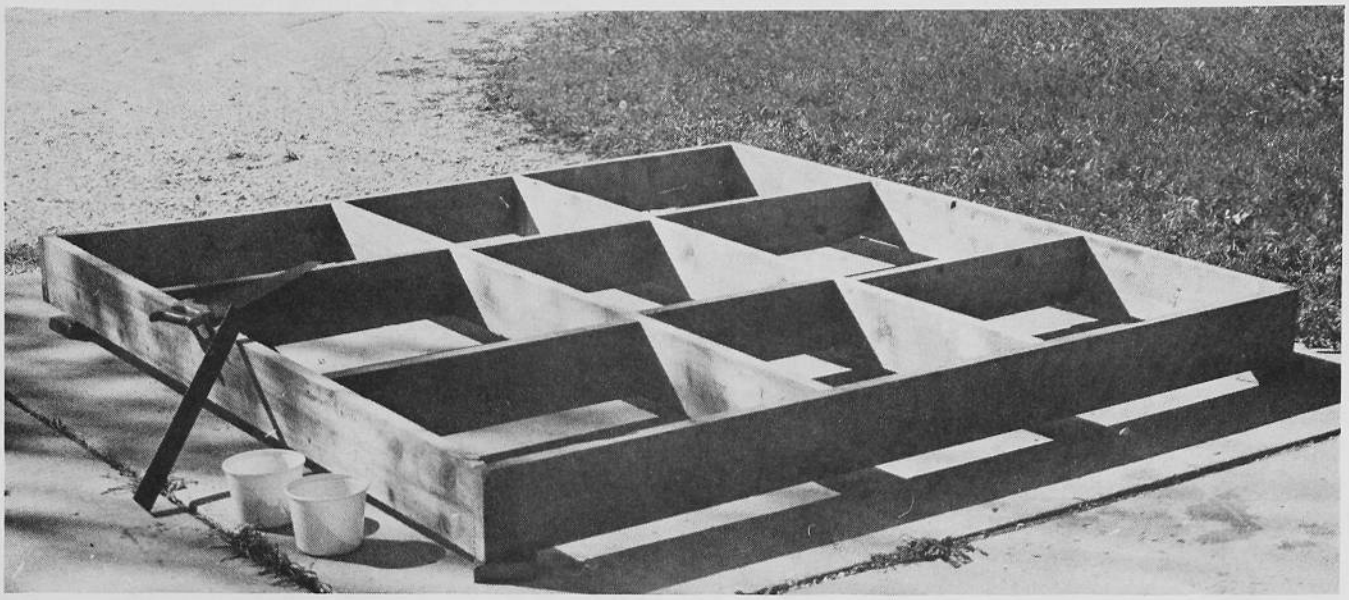
The finished observatory at the backup site. Trees shield this location from wind, my neighbor's farm yard light, and the house.

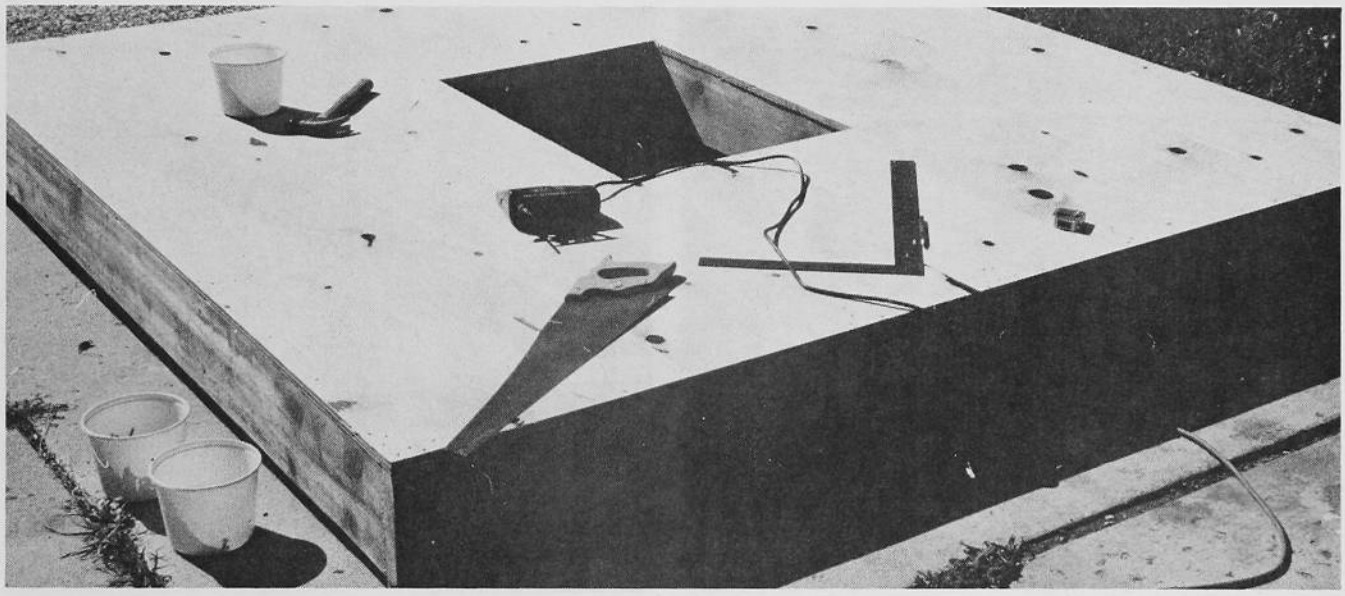
building with a 16x16-foot floor to provide sufficient point-and-walk-around space. With a small warm room on the north side, a conventional roll-off roof building spec'ed out at roughly 16x20 feet, with another 12 feet to the north for the roof track. The big observatory was getting BIG.

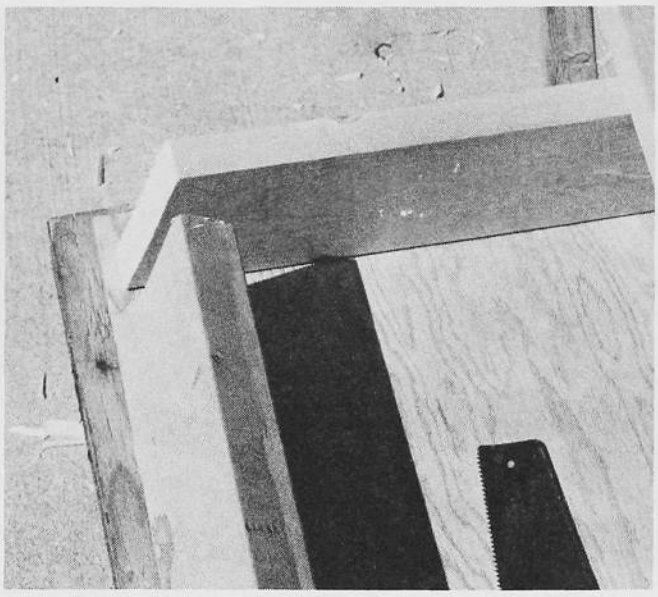
The subject of this paper grew out of my pondering. I realized I had no experience with closed observatories—my roll-off buildings never posed space problems. Instead of a "big" observatory project for a 20-inch, would I be better off building a "small" observatory for a smaller telescope to learn first-hand some of the practical problems the big observatory might entail? Wouldn't the big observatory work better if I designed it based on experience rather than guesswork?

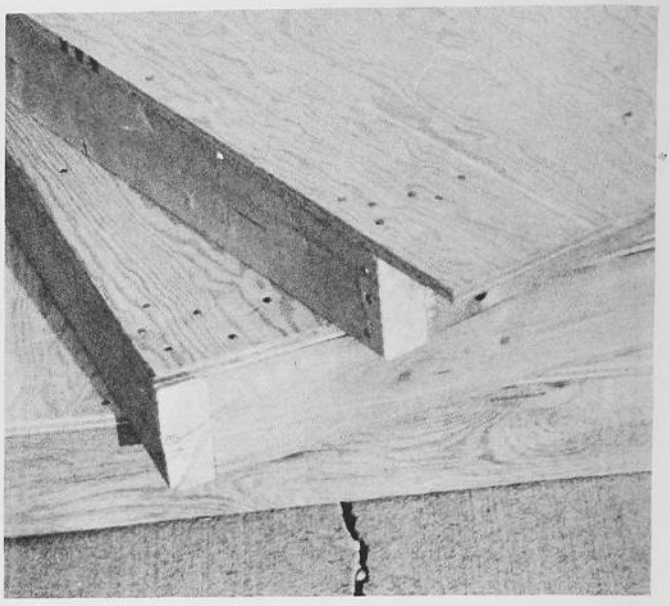
Here in the country there are few zoning restrictions. (In fact, when the building inspector came over to talk, he astonished me by stating that in his opinion, a man should be able to do anything he wanted to on his own land.) I found out that if my observatory were not a permanent structure (i.e., if it did not have a

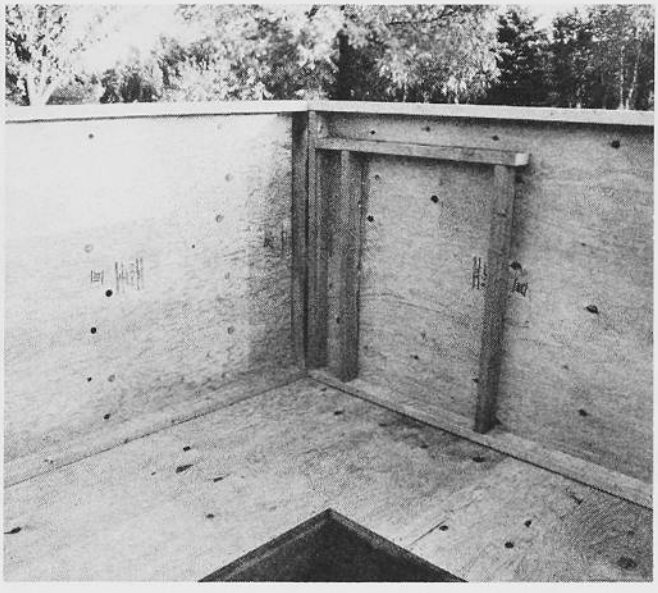
The base is constructed from 2x8s and floored over with 3/4-inch plywood. The structure was built in the driveway and later taken to the site.

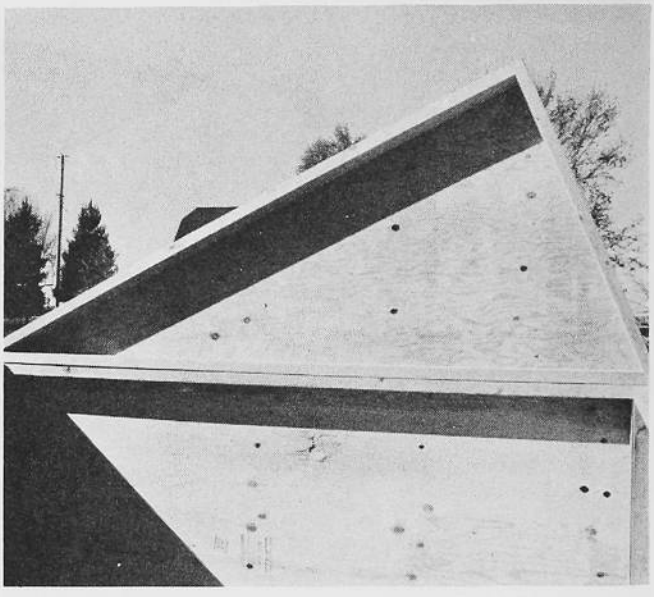












The upper folding panel on the north requires an angled 2x4 frame. The frames of all the other panels are cut square. I kept the door very simple.

foundation), there were essentially no restrictions. A 16x20-foot building without a foundation sounded like a dicey proposition, although Tom Dey's "You *Can* Take It with You" (*TM#18*) suggested several intermediate solutions that might work for me.

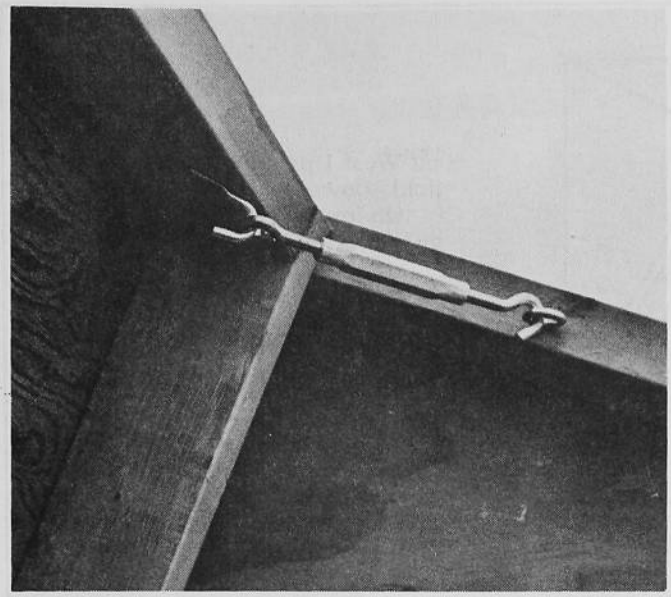
While I was in this frame of mind, two things happened. Konica announced its 3200 ISO color film that promised to make astrophotography infinitely more practical by shortening exposure times. Secondly, I saw Andreas Gada's All-Sky Observatory at Stellafane 1987 (see *TM#31*). It showed me just how compact an observatory was possible. I decide to construct a "design sketch" for the big observatory to come—while simultaneously putting my 6-inch f/5 Newtonian astrocamera into operation and testing the new high-speed film. The project would also be cheap—about $200.

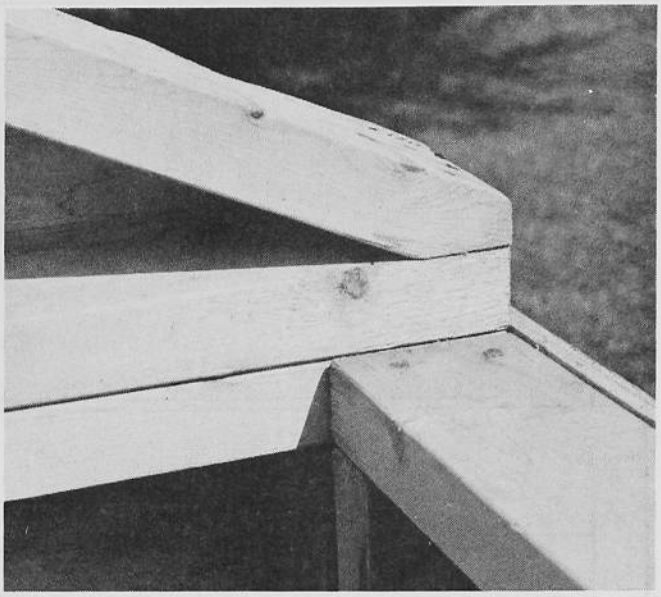
The building is constructed from eight prefab sections: a base, four fixed lower wall panels, and three fold-down upper wall panels. I designed the building to assemble (and come apart easily and to qualify as a temporary structure.

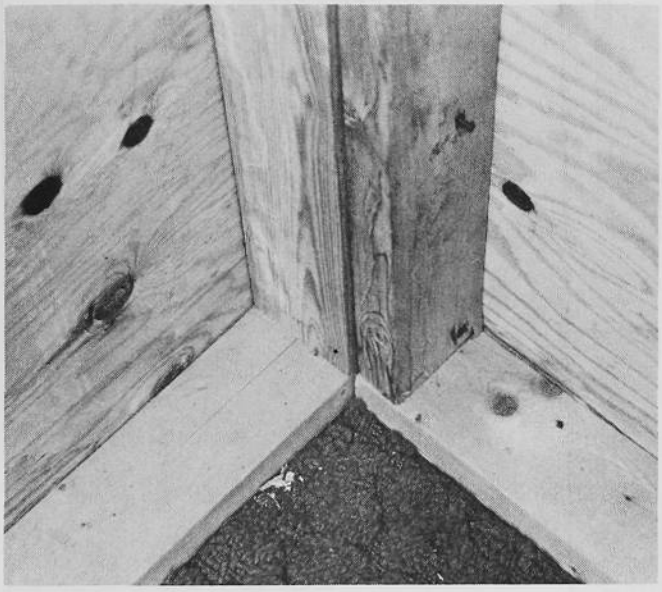
The base is an 8-foot square of pressure-treated 2x8s joined by 16-penny nails. A central opening 24 by 32 inches allows the telescope pier to sit directly on the ground. It is framed by full-length 2x8s in the north-south direction and short lengths in the east-west direction. Two 3/4-inch exterior plywood sheathings are nailed to the frame and serve as the observatory floor. The center is open to the ground.

Each of the four fixed lower wall panels is a 4x8 panel of 1/2-inch A-C exterior plywood. Two panels are framed with 2x4s on all four sides; two are framed with 2x4s top and bottom and 4x4s on the 4-foot sides. The frame members on the 4x4-framed panels are set flush with the outside edge of the panel; the short 2x4s on the other panels are inset by the width of a 4x4. I nailed the frames every six inches around the entire periphery with stay-fast nails.

To hold the door, I modified one of







Panels always join along 2x4 frames. For the fold-down panels, a turnbuckle provides a solid clamp that's both cheap and easy to detach.

these panels. After framing an opening 3 feet high and 2 feet wide in 2x4s, I cut through the panel and screwed hinges to the cutout piece. This doesn't produce a very elegant door, but it uses no extra wood. I'd advise making a surface-mount door from 3/4-inch plywood if you want the door to look nice.

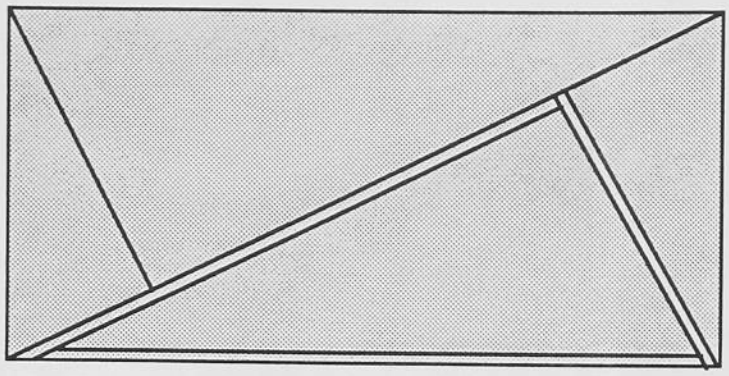
The three upper folding wall panels are cut from two sheets of 1/2-inch A-C exterior plywood. I made the east and west panels from a single 4x8-foot panel. Mark the diagonal of the panel and then drop a perpendicular from the diagonal line to remaining corners. The resulting triangles are 8 feet long on the hypotenuse and roughly 3.5 by 7 feet on the short sides. I framed these in 2x4s just as I had framed lower wall panels. The acute angles will require angle cuts in the 2x4s.

The north upper folding wall panel is 8 feet long by roughly 3.5 feet high, the same length as the short side of the east and west panels. The 2x4 frame is shorter than 8 feet by the width of two 2x4s, so this panel nests inside the east and west triangular panels when the building is assembled. I cut the side 2x4s to the 3.5-foot length of the triangular panels and then framed the panel before cutting the 4-foot dimension of the plywood. Plane one side of the lower 2x4 to make it fit.

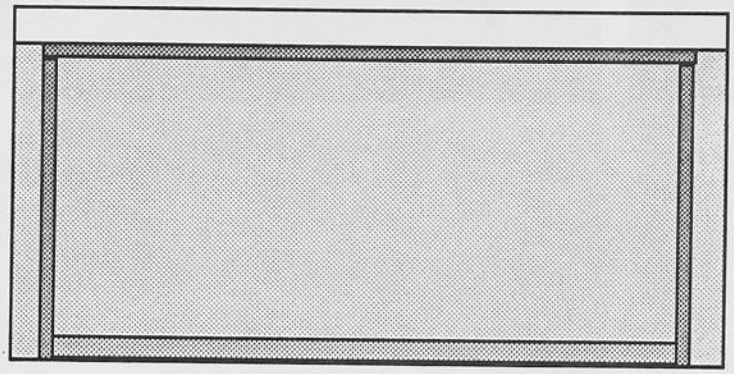
To assemble the observatory, I used double-headed nails. These allowed me to tack everything together in my garage and then disassemble the building to carry to the observing site. Lag bolts or carriage bolts would hold the building together more tightly, but the nails have worked out well anyhow.

The four lower side panels are simply set on the base and nailed to the base and to one another. Because the base is 8 feet long and the panels are 8 feet long, there will be a 1/2-inch "gap" at each corner. On my observatory I simply filled this with caulking compound after final assembly. If such infelicities bother you, adjust the dimensions of the base and panels to eliminate the gap or nail metal flashing or a wooden corner piece over the it.

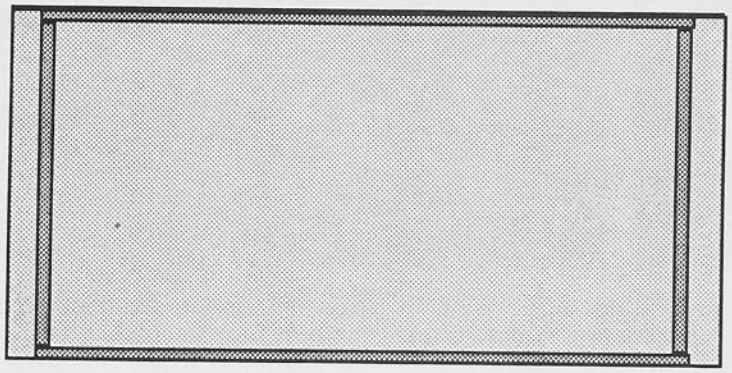
I nailed the lower part of the



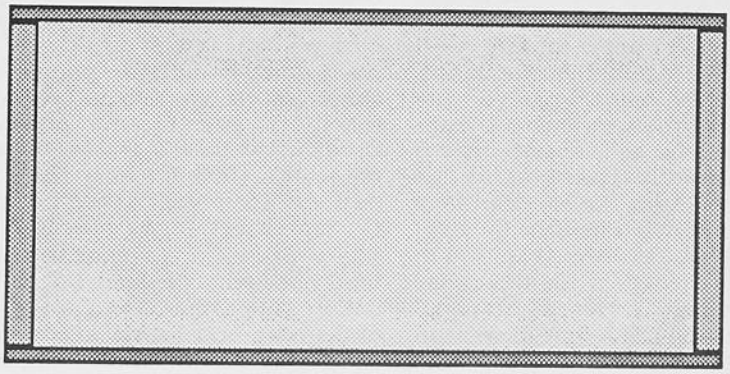
East-West Upper Panel
(folds down)
Cut two from single sheet
of 1/2" plywood



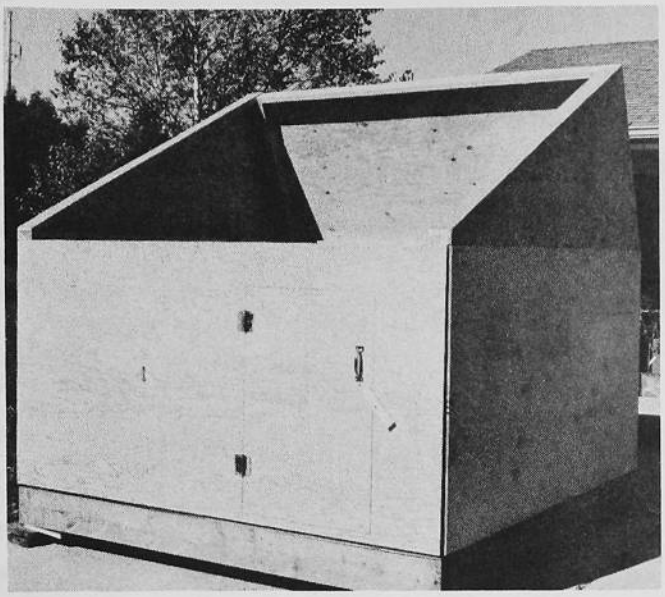
North Upper Panel
(folds down)
Sheet of 1/2" plywood cut to fit
(Note angled 2x4at bottom edge.)

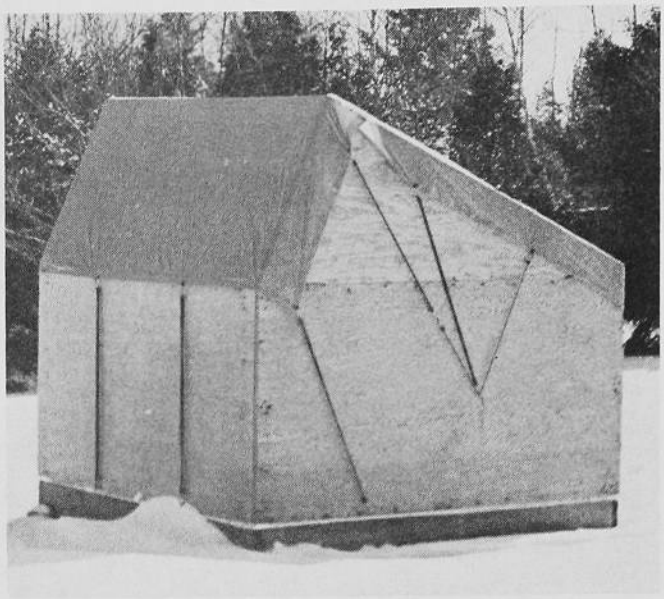


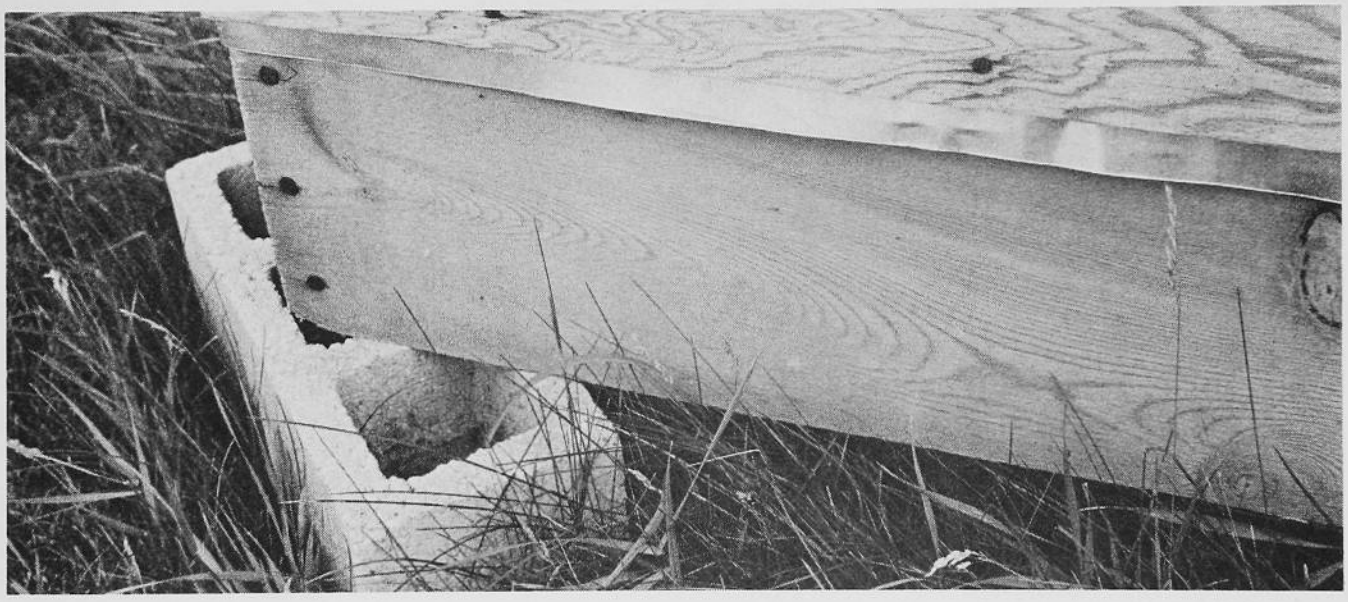
North and South Lower Panels
(nailed in place)
Make two from full sheets
of 1/2" plywood



East and West Lower Panels
(nailed in place)
Make two from full sheets
of 1/2" plywood







With its panels up, the observatory is open to the zenith and southern sky. A plastic tarp serves as the roof; metal flashing prevents a wet floor.

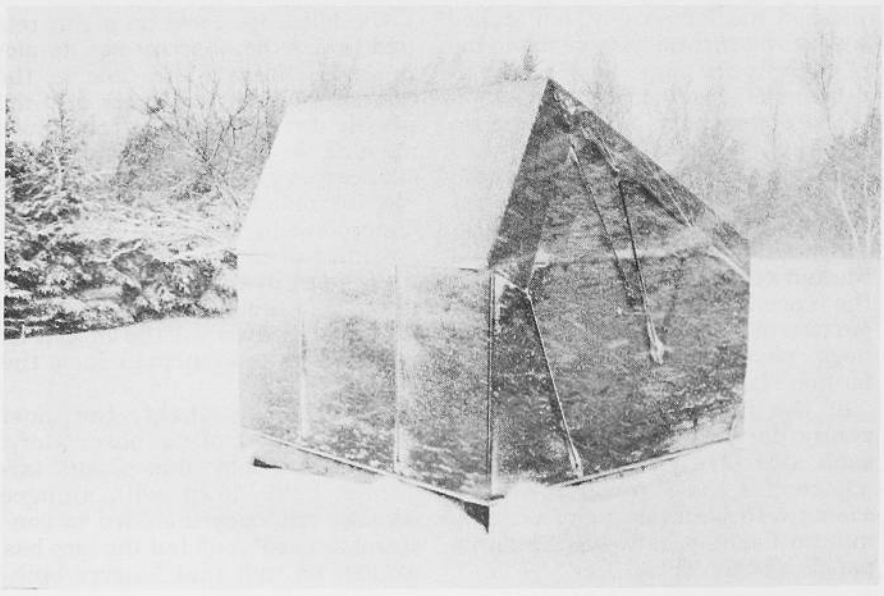
observatory together in the driveway in front of my garage. (One person can do the entire job alone, but if you can get a helper for this part, it will be easier.) To attach the upper panels, I clamped each upper panel to the lower panel as if it was folded down and then chiseled recesses for standard removable-pin door hinges and installed the hinges with wood screws. To get the correct spacing I sandwiched a piece of 1/2-inch plywood scrap between the lower panel and the upper panel being attached. Everything fit properly the first try, which pleased me immensely. I attached hooks and turnbuckles near the top of each upper panel to clamp adjacent panels together firmly.

The observatory is indeed portable: I towed the prefabbed parts to the back-up site on a trailer behind my garden tractor. The floor is set up on four concrete blocks dug into the ground to form a level support. I wanted the floor high enough that the space under the observatory isn't an attractive home for groundhogs, 'possums, or skunks, and so far none has taken up residence.

In the final assembly, six 12-penny doubled-headed nails hold each side of each panel to those adjacent. I sealed exterior corner seams with caulk and slipped aluminum flashing between the lower panels and the floor.

The telescope rests on a concrete pad under the observatory; its pier projects through the hole in the floor. I stapled two layers of 4-mil plastic to the sides of the floor opening so that although the telescope rests on the concrete, the plastic membrane between the concrete and the pier blocks the entrance of insects and small animals. I cut inserts to cover the hole in the floor around the pier with 1x2 pine foot guards on the inserts to reduce the tendency to kick the pier.

The roof is probably the most unusual aspect of the observatory: it's a 10x12-foot blue plastic tarpaulin held down with bungee cords. I originally intended to construct a "hard" roof, but the tarp has worked so well that I never both-



Can a plastic tarp fend off winter's worst? Apparently so—the secret is stretching the tarp taut so the slick plastic sheds snow. Tarp cost $4.95.

ered. It sheds rain of course and is sufficiently slick that snow usually slides right off it. There has been no leakage of rain or snow during the year since I built the observatory. On one occasion last winter snow stuck to the tarp when, on a warm night that suddenly turned cold, sticky snow or rain froze to the tarp and then fresh snow fell on top. The roof sagged about six inches under the load. I went inside and pounded on the tarp; the frozen snow broke free and slid off in an avalanche.

It's necessary to install hooks for the bungee cords where the panels

Fold back any section of the tarp and observe out the opening—or open the top completely and fold down the panels for a view of the entire sky.

will not hit them. You may have to experiment to find suitable tie-down points. I used the north and south walls for tension down the long dimension of the tarp and the east and west walls to apply tension across the short width.

The major reason the tarp works well is that the bungees keep it very tight so any wind that blows allows the bungees to take up slack that has developed in the tarp. (This surprised me: I expected that the wind would loosen the tarp and it would flap.) The taut tarp will eventual wear out, but the tarp cost $4.95 and has lasted a year so far. I keep a spare on hand.

The observatory can be used with all three of the upper panels folded down or with either the east or west panel folded down or with all of the panels up. For astrophotography, I prefer to work near the meridian with all the panels up, but folding all the panels down allows you complete sky access if you want it or east or west sky access for objects like comets.

The tarp is a versatile cover. It can be folded back entirely, opened only on one side or the other, or folded diagonally to reveal part of the sky. This allows maximum wind protection if you're observing or photographing objects concentrated in one section of the sky, such as nebulae in and around Orion.

I brought electric power to the site through a 100-foot buriable cable with 14-gauge conductors, dug into the ground about six inches. Inside the building I installed two electric boxes, one with four 110-volt outlets and the other with two outlets on a dimmer switch. The dimmer makes it easy to dial up just enough light to see what you need to see, then shut it off all from one point.

Although I don't yet have an observatory for my 20-inch, I've discovered that a "you *can* take it with you" observatory for a small telescope can be built for about $200, that 8 feet square is ample space for a one-person photographic telescope, and that a light tarp makes a good roof for a small building if it's pitched sufficiently.

— Richard Berry

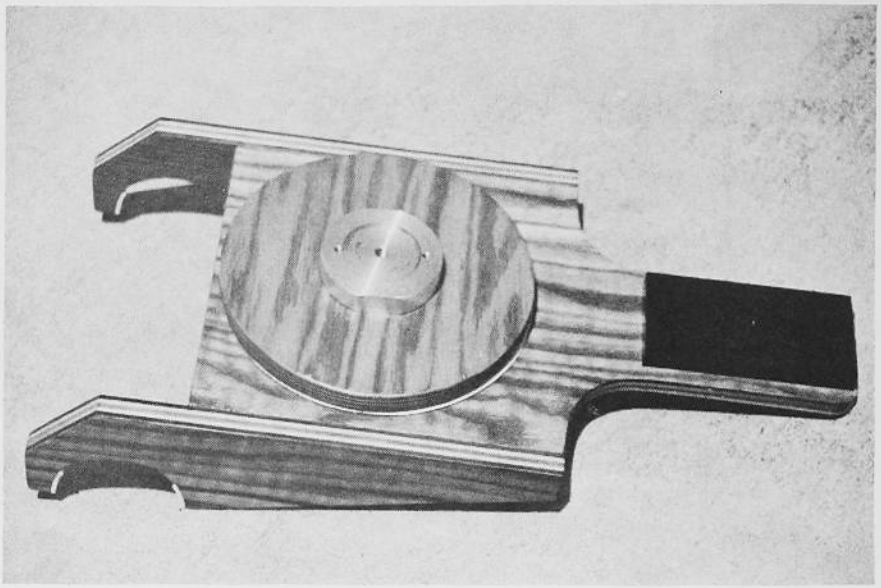
A Dobsonian Mounting for Giant Binoculars

Binoculars larger than 7x50 require some type of mounting if they are to be used in comfort. My wife Jeannie and I went through several types of tripods before we built a mounting that we were happy using our 20 x 80's on.

The first tripod we tried was simply too light to hold the large binos. It wobbled all over the sky. Our second attempt was with a much better quality video tripod, but it just wouldn't tilt upward enough to allow to look high in the sky. While looking for our third tripod, we got something that we thought only applied to new automobiles—sticker shock—we came across many with price tags over $400.00. We were even considering building our own when we came across tripod number three: a tripod that was not only sturdy but also went high enough. After using the new tripod for 6 months we were still were not completely satisified.

What bothered us was constantly unlocking and locking knobs and handles in order to set the binos where we wanted them. When we went to observe anywhere near the zenith, it got very awkward since the eyepieces get too close to the tripod legs.

What we needed was a mount that would hold the binos out from the tripod so looking high would be easier. We also thought it would be nice if the binocular mounting would work just as easy as our large Dobsonian. Then we could easily pan around the area of the sky were were searching and let go at anytime—without locking any knobs—and the binos would just stay exactly where we left them.

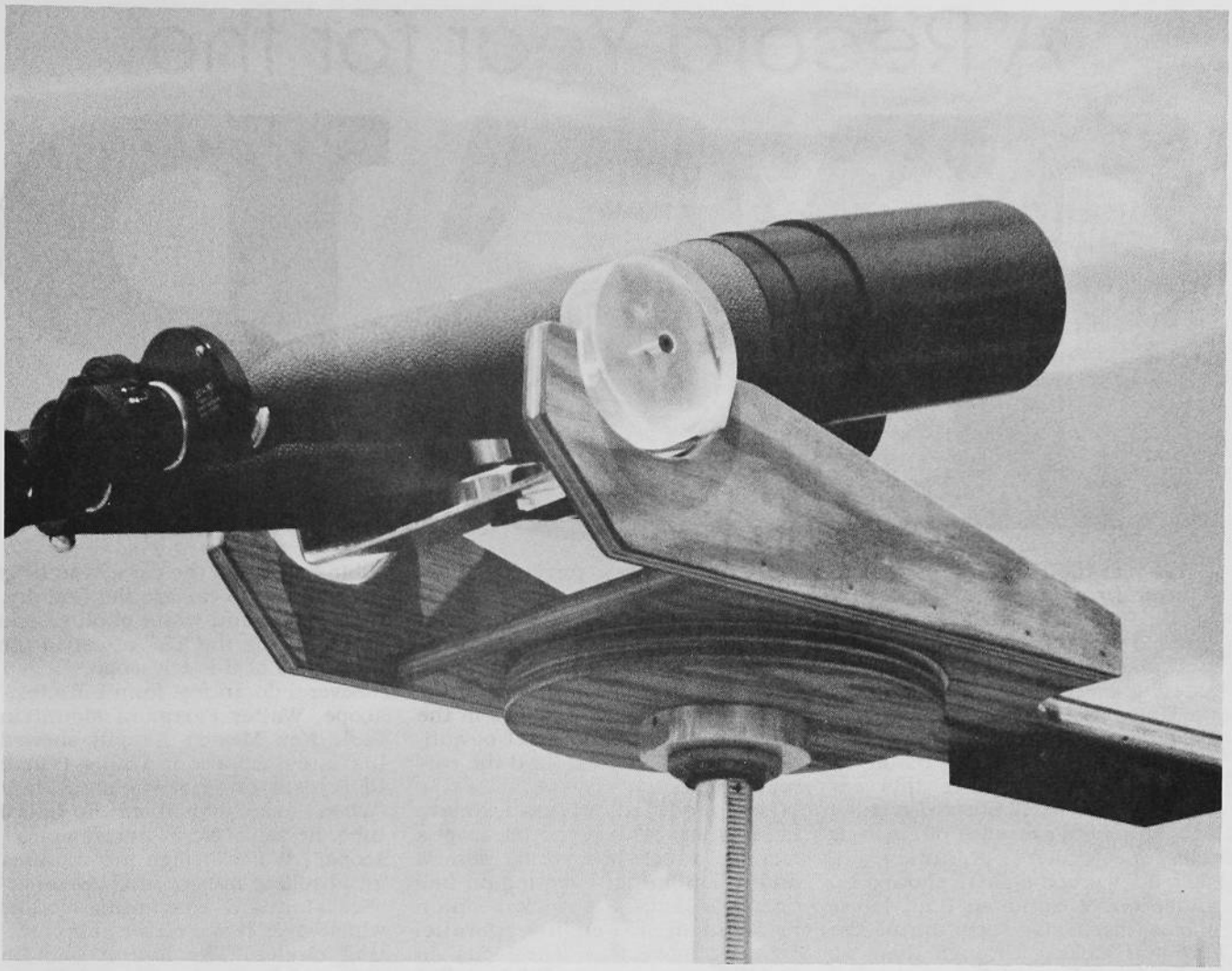


After just a few sketches and several hours work, the mount shown in the pictures was built. It is made of scrap oak plywood and whatever else was on hand in the shop. An aluminum block on the bottom is drilled and tapped with a 1/4-20 thread that fits the mounting thread on the top of the tripod. Two separate screws hold the block to the round board, and the top assembly pivots on a screw that is threaded in to the top of the aluminum block. If you shop carefully you will find that you can order your tripod without the head, and that will save you a considerable amount of money.

The mount is Dobsonian in design. The upper part rotating on the round base with Teflon and Formica for bearings. There are three Teflon pads nailed to the round bottom board. Use a nailset to make sure the finishing nail heads are below the top of the pads. The Formica is glued to the bottom of the top board with contact cement.

The altitude trunnions are made of a scrap of plexiglass and screwed to a piece of 1/8-inch aluminum bent in a vice with a hammer. You could use wood and PVC fittings just as easily. Make sure that the trunnions are approximately in the middle of the binoculars. If they are too high or too low, they won't balance correctly.

The distance from the center of the pivot point to the altitude trunnions is half the distance of the distance from the center pivot to the center of the counterweight. Therefore the counterweight only has to

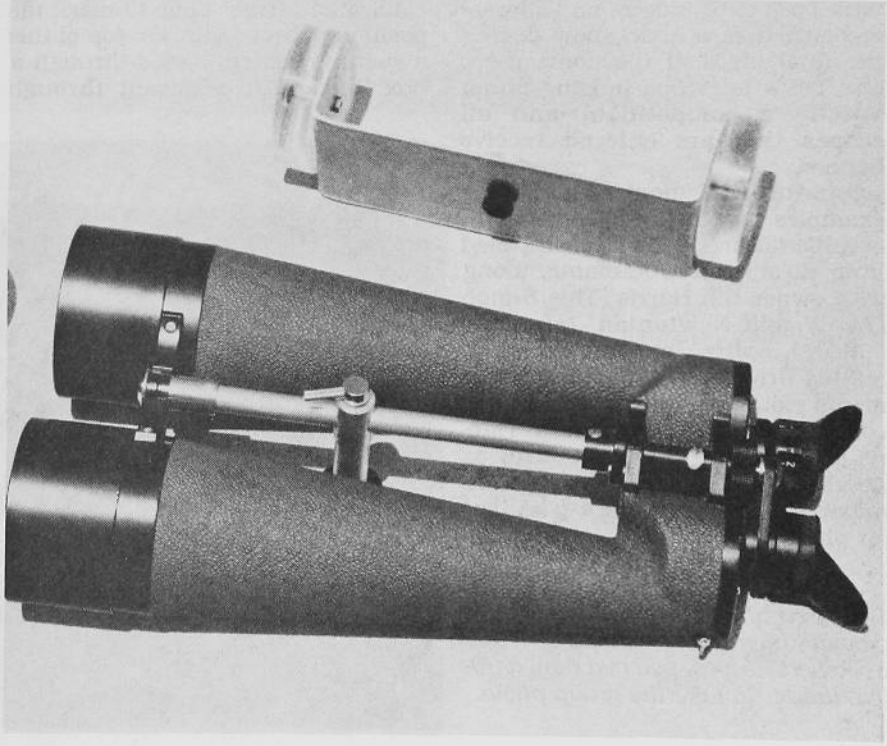


To use large binoculars, you'll want smooth motions and freedom from clamping and unclamping the axes. This binocular mount does the job.

weigh one half as much as the binoculars to balance perfectly. We used a scrap piece of cold-rolled steel 5/8" x 3" x 6" that weighs 3.2 pounds—just right for our purpose. This weight doesn't have to be exact, but just enough to balance the binocular so it turns smoothly on the top of the tripod

This mount moves very easily, and amzes everyone who tries it. There is no vibration at all which makes the images very steady. You could use wooden legs, but the crank that raises and lowers the tripod head is almost a necessaity for binoculars, so I would recommend using a photo tripod under the Dobsonian mount for this feature alone.

Tom Clark
2111 Whitfield Park Avenue
Sarasota, FL 34243



A Record Year for the TSP

This year the Texas Star Party had a record-breaking year. From May 8 to 15, 1988, the Prude Ranch in Fort Davis, Texas—just a few miles from McDonald Observatory—hosted 625 amateur astronomers from all over the United States for seven nights of clear, dark skies.

Despite the star party's billing as an "observer's convention," this year the telescope fields showed a small but influential presence of amateur telescope makers. A number of skilled telescope makers showed up and proudly exhibited their latest efforts, discussing them during the day and looking through them at night. Two dozen ATMs registered telescopes to be judged, and all were recognized in a slide show during the final night of the convention. The TSP's telescope judging is not strictly a competition, and all scopes that are entered receive honors.

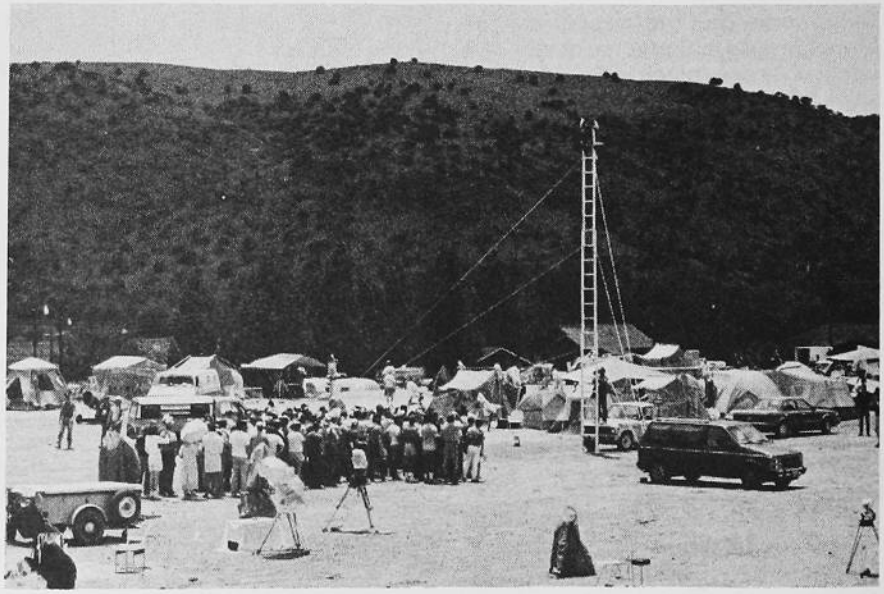
One of the most remarkable examples of a modern astrophotographic telescope I've seen traveled from Birmingham, Alabama, along with owner Bill Harris. This 8-inch f/4 Wright-Newtonian telescope features optics by Paul Jones, a Mathis drive, and a Pacific Instruments mount. Although some of the components aren't homebuilt, Harris fashioned an incredible array of accessories on the telescope to maximize the telescope's potential for photography.

Bill built a drive corrector inside the telescope's pier and a power supply that permits astrophotography anywhere he takes the telescope. A pair of rheostats mounted on top of the telescope control the brightness of the cross hairs in the guiding eyepiece and a set of anti-dew resistors fitted around the corrector plate.

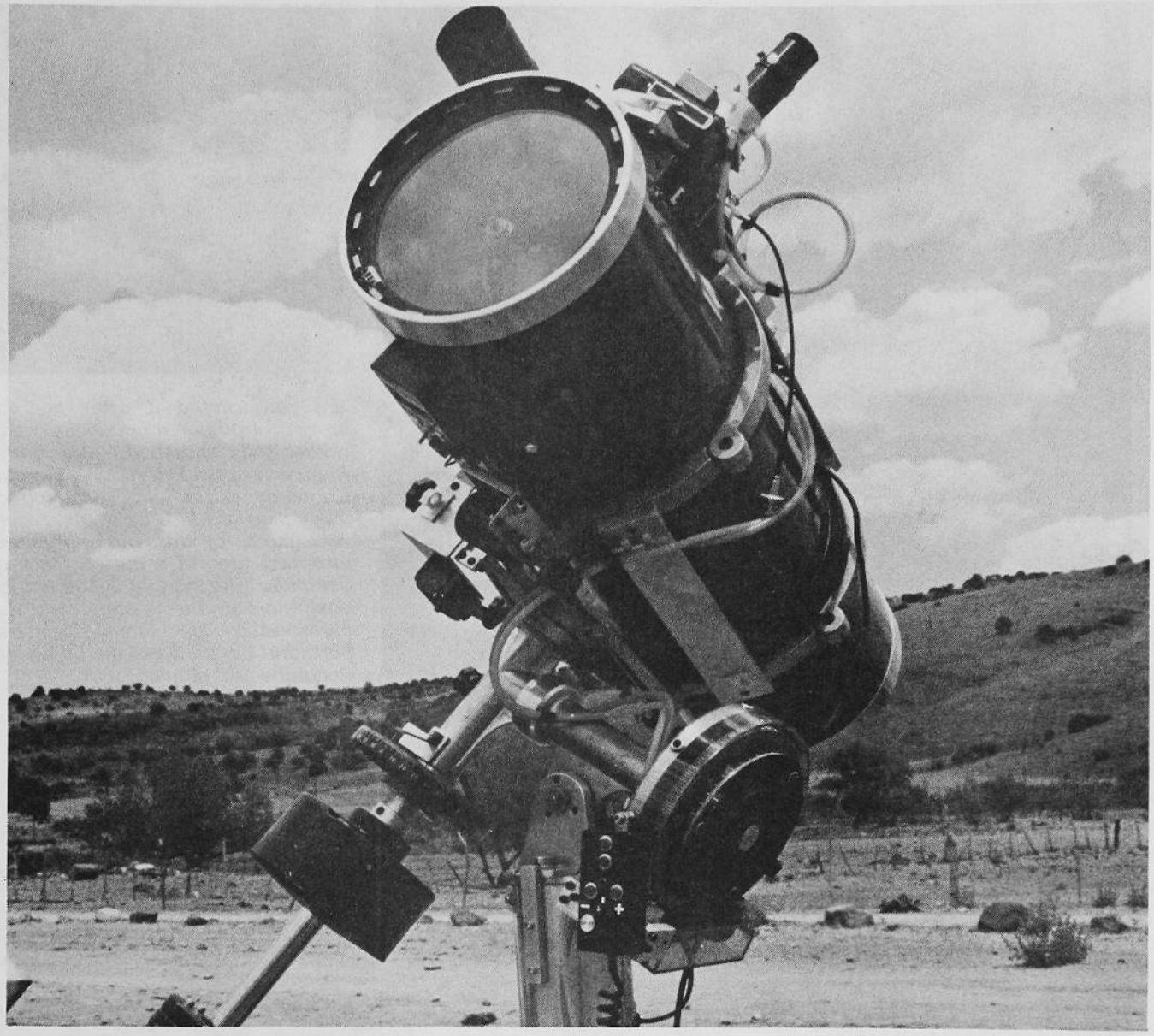
The modified 35mm camera mounts low against the telescope's focuser, which has corner screws and a bottom plate resting on ball bearings and a sprocket chain mechanism to ensure parallel focusing movement. The focus, in fact, is reproduceable: Bill installed calibrated vernier dials to mark the position of best focus. On top of this a vacuum system cycles through a box filled with desiccant through tubing and into the camera to keep the film in the camera flat and dry. Bill's black-and-white photographs made during the TSP attest to the excellence of this telescope.

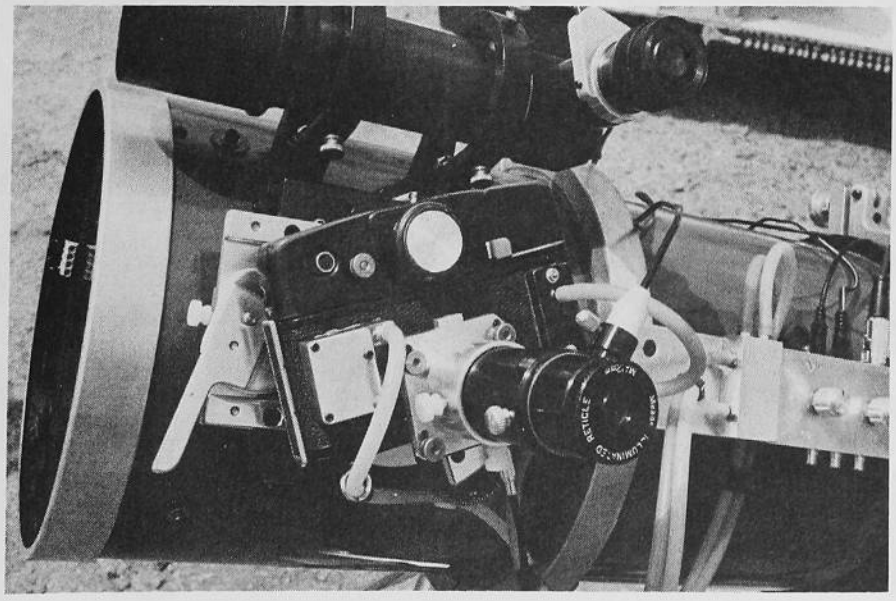
Several dozen feet from Bill's telescope, Walter Farrar of Mountain Park, New Mexico, happily showed his latest creation. Walt's 6-inch RFT rests on a novel mounting. (When I asked him about the optical tube, he said: "Never mind the telescope!") Walt's design incorporates an armillary sphere into the otherwise standard altazimuth mount, which gives him a clever pair of setting circles. The mount can be adjusted to work at any latitude between 70° north and 70° south, and it works beautifully.

To find an object, Walt first aligns the mount then sets the inner of two



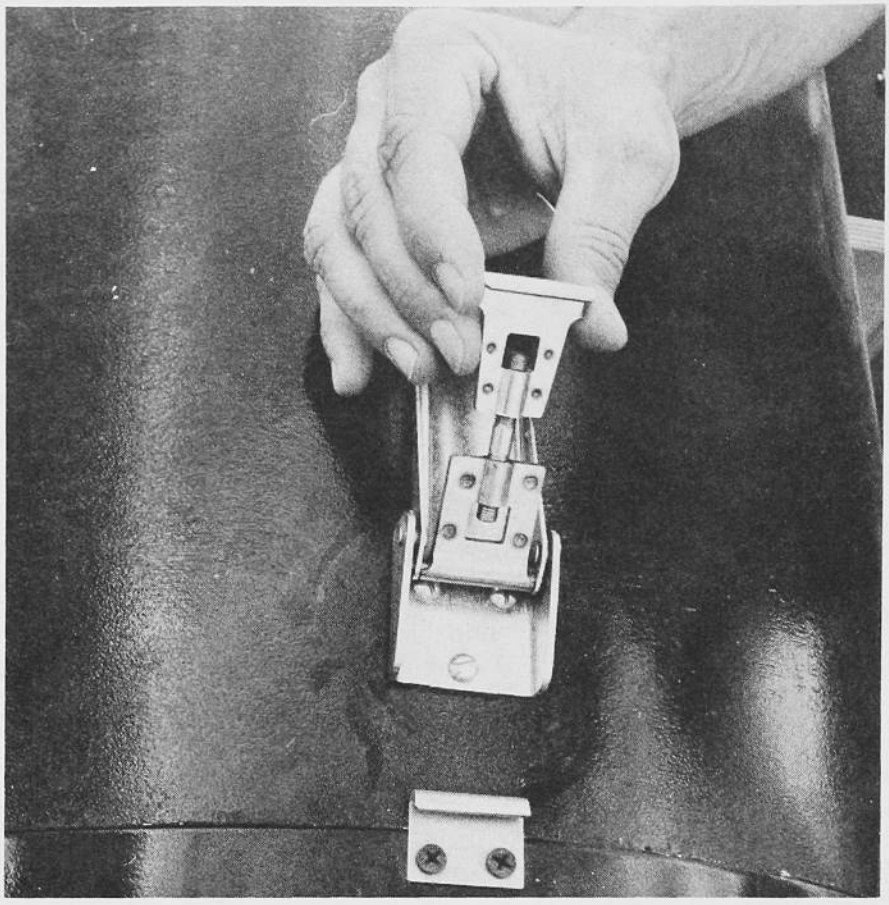
The spirit of the Texas Star Party: A crowd gathers in the shape of Texas as Robert Reeves, perched atop a 30-foot ladder to take the group photo.

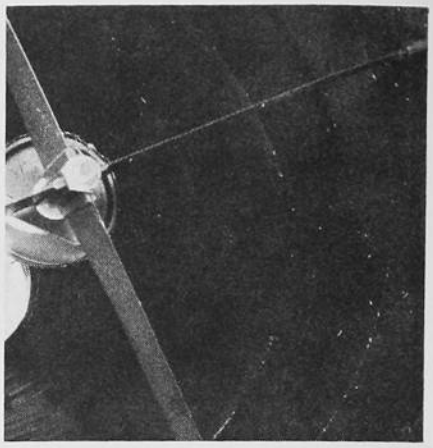




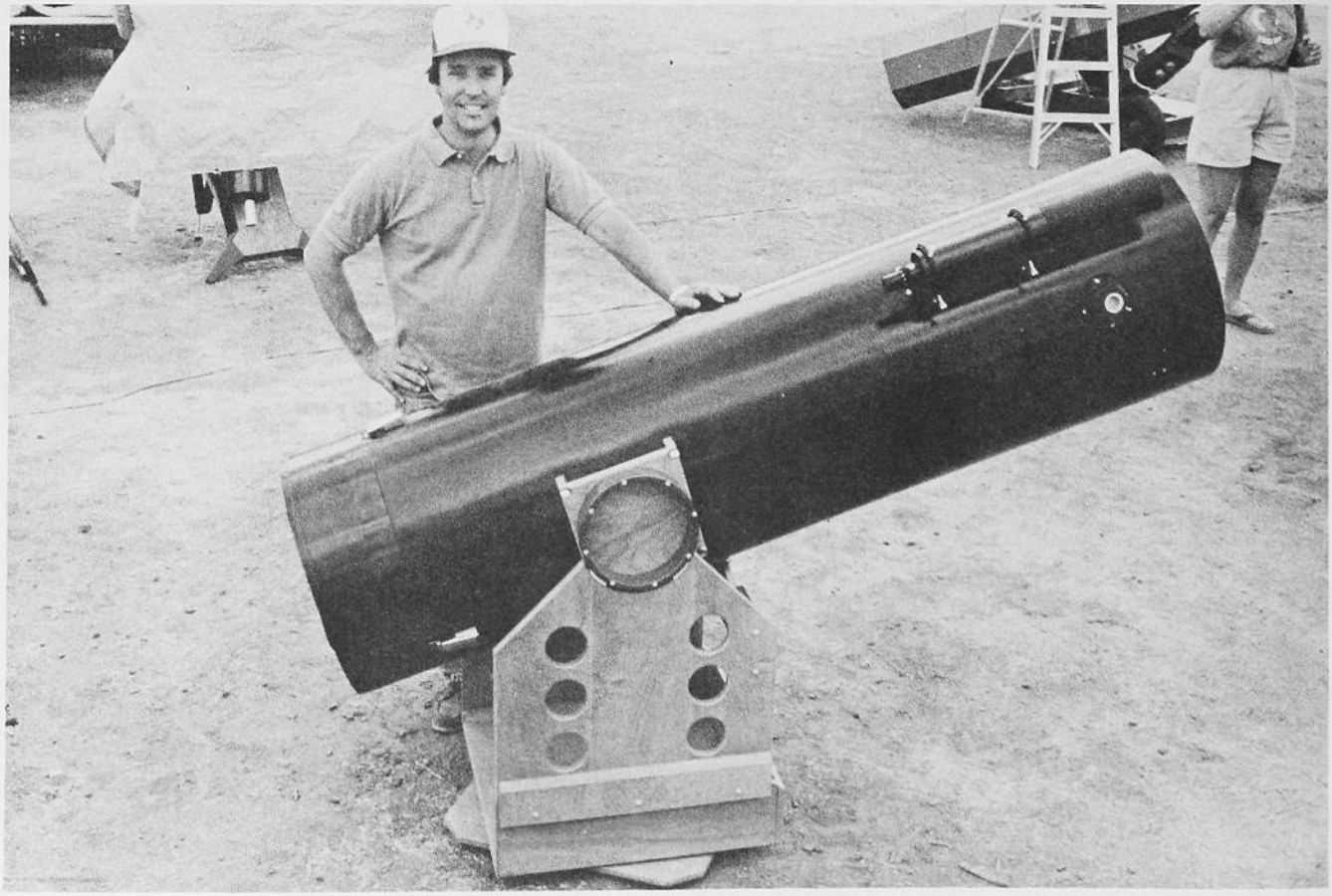
TSP88

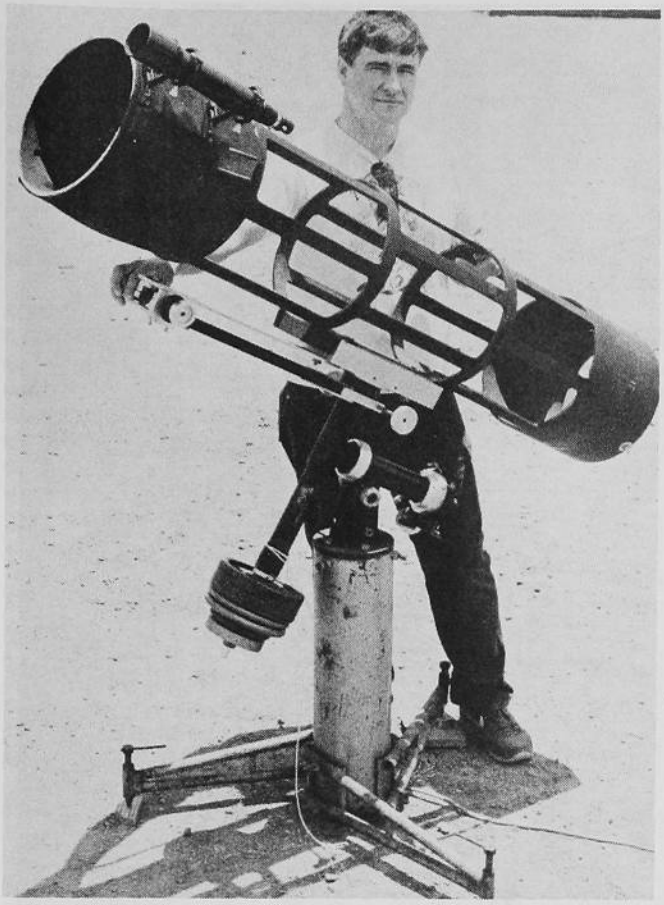
Bill Harris' 8-inch f/4 Wright-Newtonian features an impressive array of custom-machined accessories. The drive corrector, focusing mechanism, antidew resistors, guiding eyepiece, and camera were machined or heavily modified by Harris. Small photo shows the telescope's "business end" with the rotatable camera and built-in off-axis guider. The rubber hoses run to a vacuum, which holds the film flat and keeps it dry in the camera. The resistors are visible next to the scope's corrector plate.





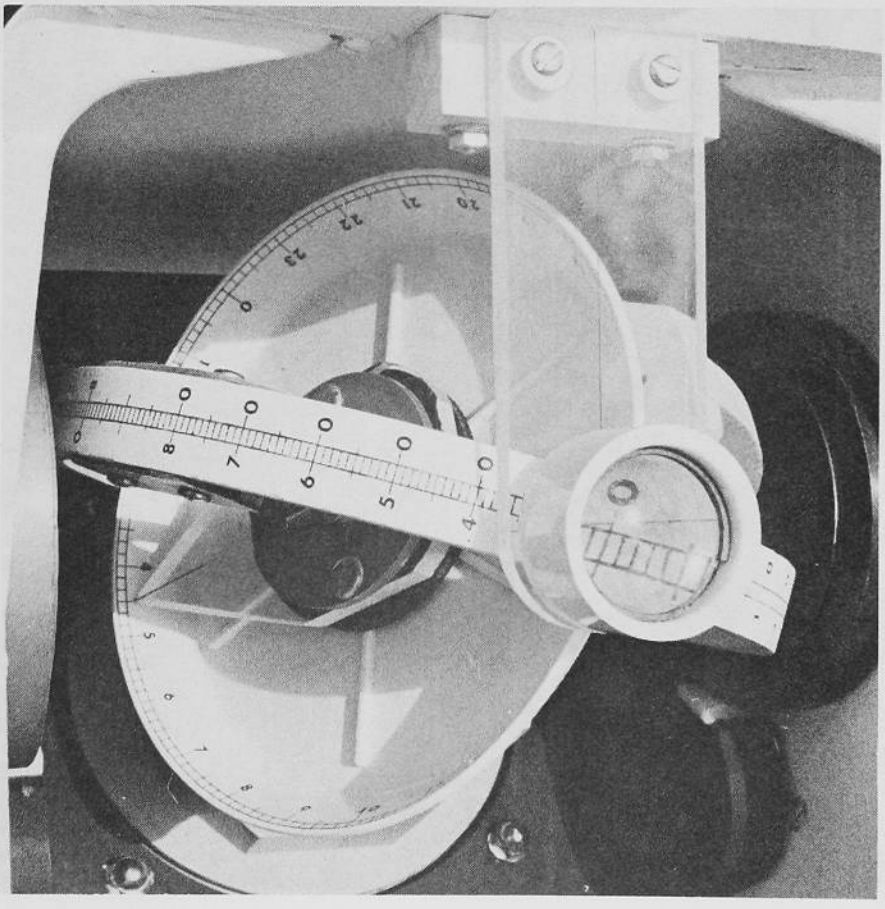
"I reconstructed it after my old scope, a traditional Dobsonian, was accidentally smashed," said David Knowlton of St. Petersburg, Florida. Knowlton did a very nice job of revamping this 17.5-inch f/4.5 scope, now made of thin birch plywood wrapped around a gutted piece of Sonotube. The mount folds down for easy storage. Insets show how the mirror cell can be taken off for transport, and the inside of the tube with Sonotube and plywood.



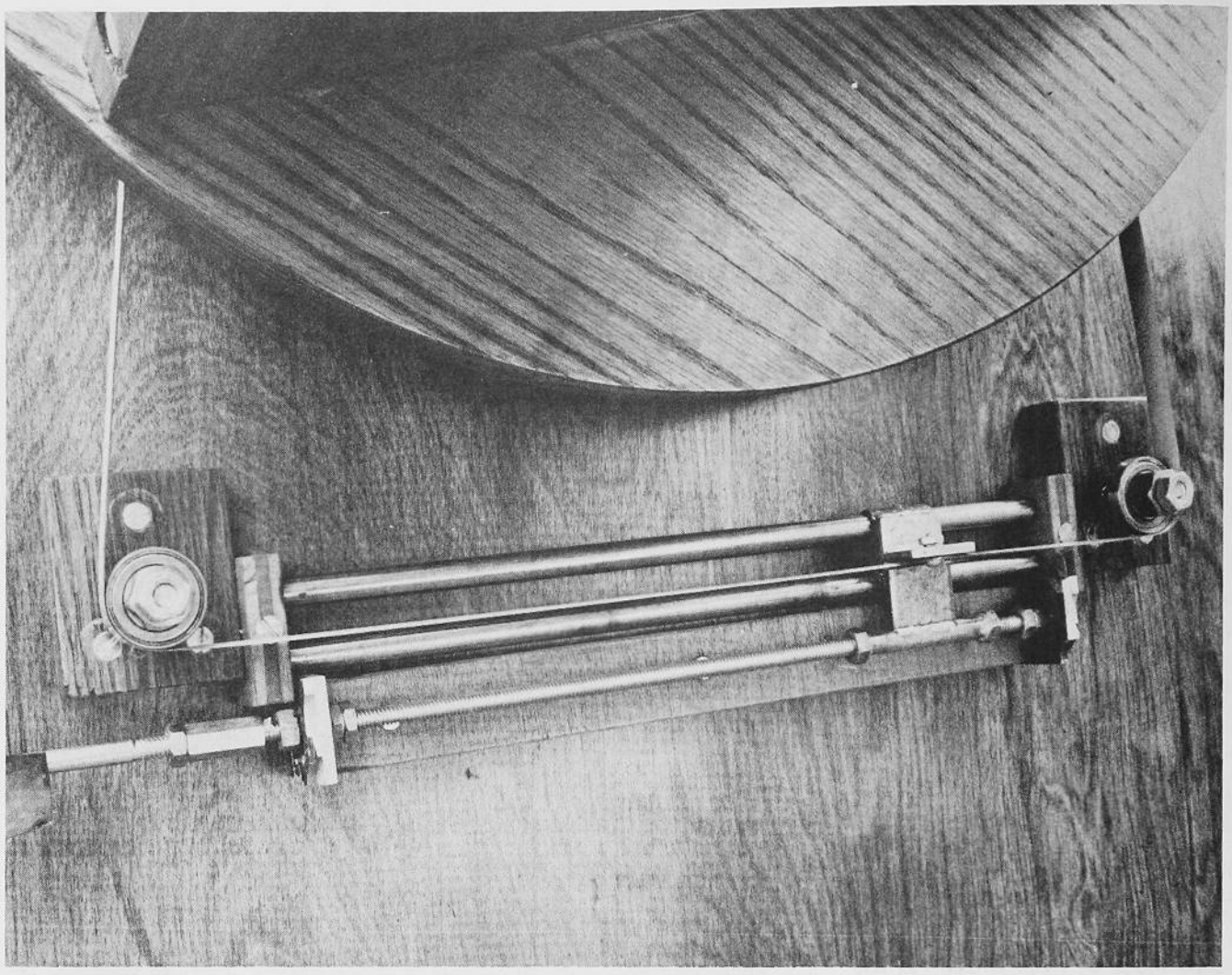


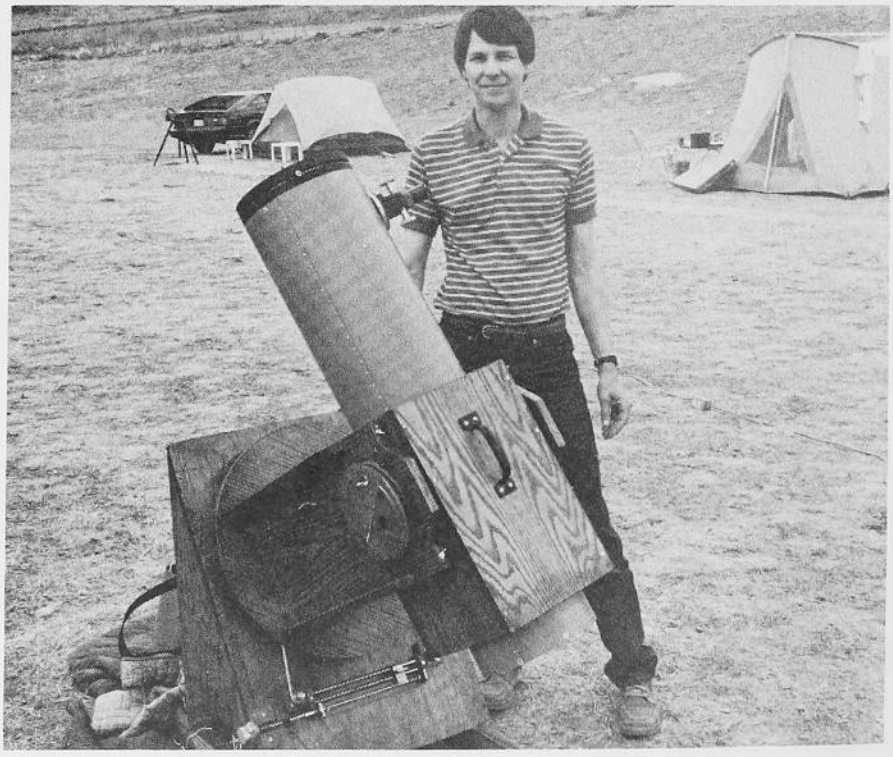
Above: Big Newtonian reflectors were scattered all across the fields at this year's TSP. One of the nicest was Kenneth Drake's 10-inch f/5.6 scope made of PVC. Drake cut the PVC tubing to minimize weight and keep the scope as portable as possible. The only heavy part is the mount, which Drake uses for astrophotographic guiding.

TSP88



Right and above right: Walter Farrar had the most novel telescope mounting at this year's TSP. Farrar's 6-inch RFT rests on an altazimuth mount that uses an "armillary sphere" to locate objects like setting circles. To find an object, the inner circle is set to sidereal time. Next, the outer circle is set to the object's right ascension. Finally, a magnifying glass floating over the outer circle's scale is used to set declination. Photo at right shows a close-up of the armillary sphere.





TSP88

Tom Pock's 8-inch f/5 reflector rides atop a 12-inch lazy Susan disk that turns on an old phonograph table. The telescope's drive is made from a metal measuring tape, and the setting circles are protractors. According to Pock, "it works beautifully, without periodic error." Photo above is a close-up of the tape drive mechanism. A homemade variable-frequency drive corrector that cost $Pock 35 to build runs the motor.

circles to sidereal time, furnished by a digital clock affixed to the mount. The outer ring is then set to the object's right ascension, and declination is set with a small magnifier mounted above the outer ring scale. After doing this procedure, which takes only a few seconds, the object lies in the telescope's field of view.

Of the many Newtonians on the telescope fields, Kenneth Drake's 10-inch f/5.6 reflector showed outstanding tube work. Kenneth is an active member of the Houston club who lives in Conroe, Texas. He explained that the telescope "used to be a Dobsonian, but I found I wanted to convert to an equatorial." The scope features a PVC tube with cut sections to minimize weight. Most of the accessories mounted on the tube are from Kenneth Novak, and a Telrad sits next to an optical finder. It seems to me, at least at the TSP, that Telrads have become standard equipment on any telescope larger than 4 inches in aperture.

David Knowlton of St. Petersburg, Florida, brought another fine reflector. Knowlton's scope consists of 17.5-inch f/4.5 Coulter optics that had been mounted as a traditional Dobsonian before "the accident." Knowlton explained that after his telescope was "smashed," he decided to rebuild it with some revisions. The scope's tube is made of thin birch plywood wrapped around a gutted piece of Sonotube. The smooth side bearings are PVC on Teflon. The mirror rests on nine silicone pads and can be collimated with three wing nuts resting behind compressed springs. The mirror cell attaches to the tube with three steel clamps and is detached for transport. The entire mount folds up into a very small package, which makes it a "wonderful telescope to haul across the country."

The cleverest drive at this year's TSP was built by Tom Pock of Austin. Tom mounted an 8-inch f/5 reflector onto a tipped lazy Susan platform and rigged a drive using a steel measuring tape. The tape circles around a phonograph table, driven by a 1/2 r.p.m. motor. The first thing I heard after walking up was Tom saying that the drive is so smooth "you can turn it with your pinky." Indeed it was. Tom also constructed his own drive corrector for the telescope, which cost only $35 to make.

One of the great attention-getters this year was the massive 14.5-inch f/4.1 binocular telescope built by Robert Suding of Conifer, Colorado. (It was shown at the Riverside Telescope Makers Conference two weeks later, and pictures of it appear in Richard Berry's article in *TM#33*.) Called the "Star Cannon II," Robert's telescope is a well-crafted homebuilt machine made of red oak and aluminum struts that allow the whole thing to be disassembled. The matched mirrors were made using the same tool by Galaxy Optics in Boulder, and the telescope carries a 102mm commercial SCT as a finder scope.

Following the ideas of Lee Cain's binoculars telescopes but adding several unique features, Robert constructed the telescope to be functional for any observer. In a talk he presented at the TSP, Robert explained that "the most critical factor in binocular telescopes is the placement of the eyepieces. I used rotating rings with attached eyepieces so anyone can easily adapt the telescope to his or her eyes." The rings rotate on metal bearings and are held in place by rubber bands. The telescope uses old bicycle training wheels at the base for easy portability in the field and has a handy Plexiglas holder on the base for star maps. To explain his effort, Robert said, "Your life will never be the same after looking through a binocular telescope!"

This year's Texas Star Party of course emphasized observing. Hundreds of people walked from telescope to telescope with the aid of dim red lights, hoping to see things they'd never seen before. But the appearance of a number of finely crafted, innovative telescopes this year suggests that observing may not be the only claim to fame for future TSPs.

— David J. Eicher

The TSP is held at one of the best deep-sky sites in the U.S. Bill Harris photographed dark and bright nebulae near rho Ophiuchi at the TSP.

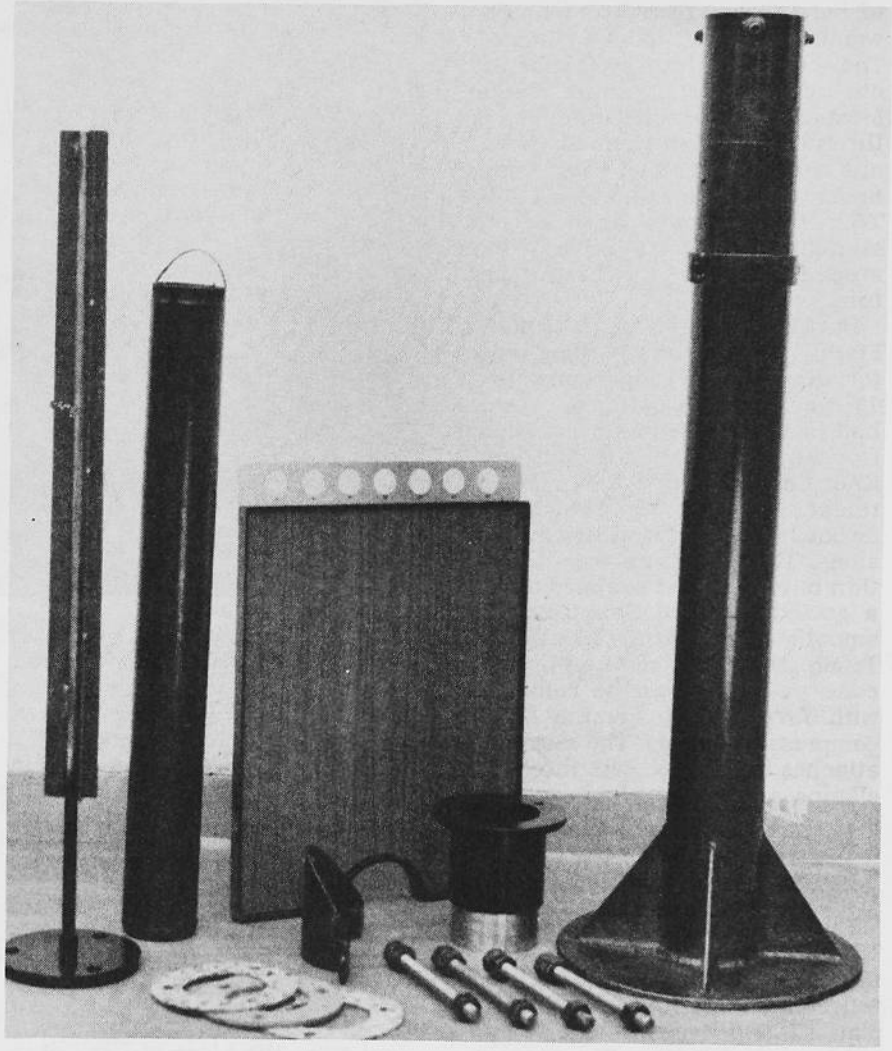
A "Dampier" Pier for Vibrationless Telescope Support

Although the top of a tall building may seem like an obvious location for an observatory, vibration often presents a severe problem at such a location. At my home I encountered this difficulty with my 11-inch Celestron. By mounting it on top of a damped pier, or "dampier," I strongly reduced the vibrations reaching the telescope.

Many delicate instruments, particularly telescopes, must be protected from the vibrations produced by automobiles on the street, elevators, machinery in the basement, and vibrations from other sources always present in a building. In most cases the vertical components of these vibrations are harmless and can be ignored. Although the effect of the horizontal components on a telescope may be small, it is necessary for the most delicate work to eliminate these horizontal components as far as possible by mounting the instrument on a vibrationless support.

The problem involved in obtaining a suitable pier are similar to some of the problems encountered in designing a seismograph; indeed, anyone planning to develop a vibrationless pier of his own design will find the literature on seismographs helpful.

Briefly, all vibrationless supports can be considered oscillating systems loosely coupled mechanically to the floor of the room. The shielding effect of the support is determined by the resonance between it and the floor. For example, if the natural period of oscillation of the support is long compared to that of the vibrations of the floor, it will be so far out of resonance that its response will be feeble, and it will not be excited into vibration. It is necessary, of course, for the support to be damped so its own natural oscillations will be suppressed.



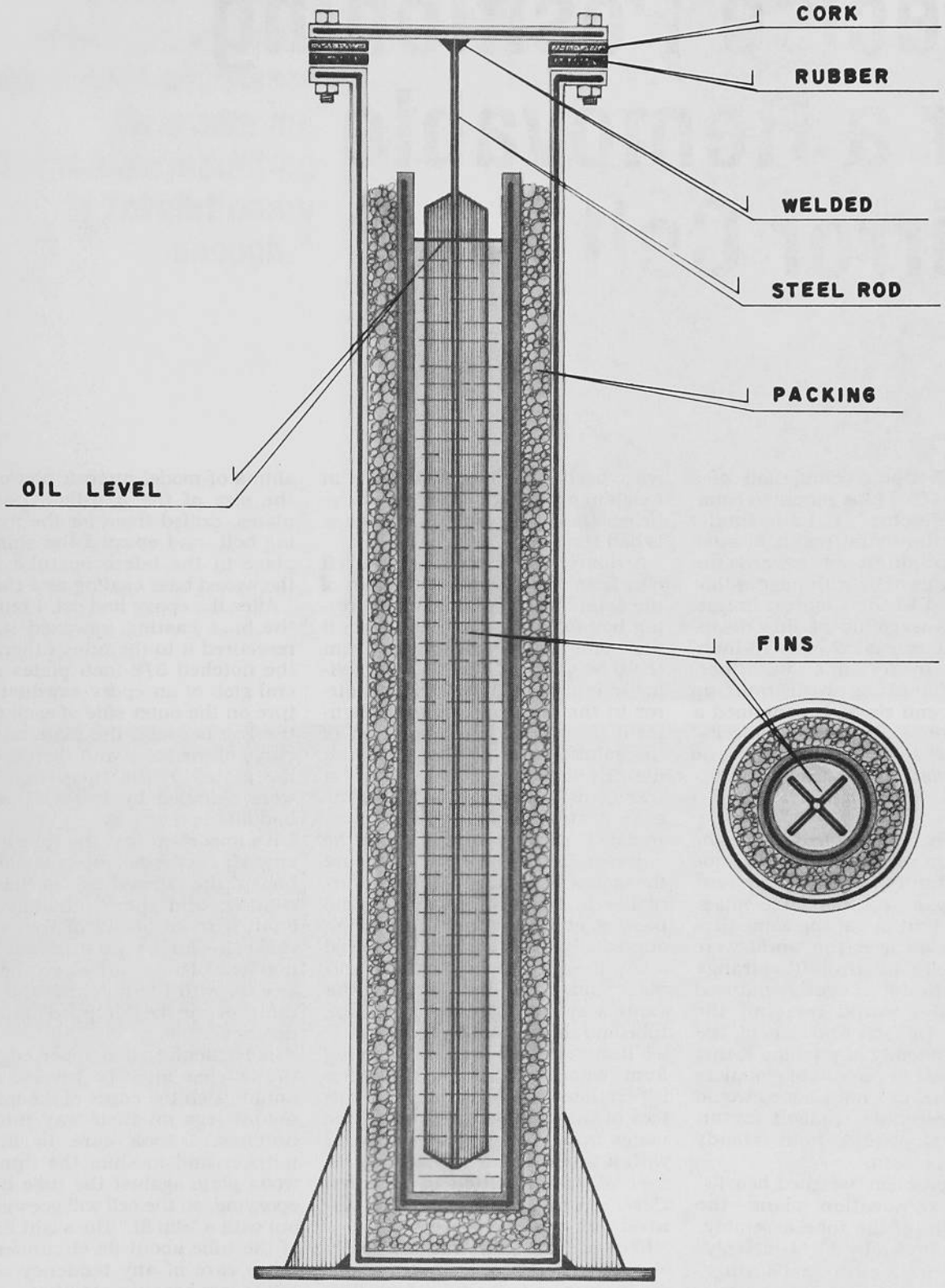
Damping is easily obtained from the internal friction and viscosity forces in oil. Naturally one selects the most stable place for mounting the vibrationless support. A pier that has a separate foundation from the rest of the building is ideal.

My successful design for a "dampier" is shown in the photographs and drawing. Heavy viscous oil was used. The inner container was filled to the height observed to produce maximum damping of the natural oscillations of the system.

The advantages of this system are simple design and that it doesn't block the motion of the telescope.

Rafael López Vélez
Mar Mediterraneo No. 45
11410 México, 17 D.F.

A SPRINGLESS "DAMPIER"



Precise Positioning for a Removable Mirror Cell

In 1977, upon completion of a 12.5-inch f/5.6 pipe-mounted equatorial reflector, I had finally achieved the usual result of such ambitious plumbing toward the stars: a large optic with images that succumbed to the slightest breeze. The tube assembly of this disappointment consisted of a 16-inch-diameter by 77-inch-long fiberglassed Sonotube with built-up fiberglass end rings. It contained a 1:6 mirror in a Novak flotation cell—altogether a hefty package. The problem was that 4-inch pipe fittings just couldn't handle such a load.

After a year or so of frustration the Dobsonian revolution offered me the opportunity to reoutfit my venture into what was then large optics. (I suspect that about the same time junkyards all over the world were beginning to fill up with strange configurations of gaily painted plumbing.) I would remount the tube *a la Dobson* and accept the seeming difficulty of pushing it this way and that in pursuit of globulars and nebulae, in what I hoped would be an acceptable tradeoff for an image that would hold steady enough to be seen.

Yet one problem "weighed heavily" upon the renovation plans—the gross weight of the tube assembly, when surrounded by a 3/4-inch plywood box and altitude bearings, would top out at over 100 pounds, with perhaps 65 pounds of that weigh in my end (to offer your carry-helper the mirror end of a telescope is bad etiquette).

A dusty length of Sonotube left over from the tube suggested part of the solution: I would make a carrying box for mirror and cell from it and remove the heavy optics from the tube after each use. I was looking to remove and reinstall the mirror in the telescope without alignment problems. The other part of the solution was suggested by the mirror cell itself.

The cross section of the legs of the base casting of the cell is trapezoidal. These legs are tapped at the ends for 5/16-inch bolts to secure the mount in the tube. As Novak furnishes it, the casting's trapezoidal base is at the bottom. The shape suggested a "key" system that would allow the legs to be dropped into place time after time exactly the same way, in both the telescope tube and the mirror storage box.

I first removed the base casting from the cell and reversed it so the leg sections tapered toward the bottom of the mount. I next cut three plates from good 3/8-inch plywood with a tapered notch in each to fit over a leg and fitted each notch closely to a leg and sealed the plywood with epoxy.

Because the cell was originally slightly undersized, it needed washers to snug up to the tube. I cut thin shims of model aircraft plywood to the size of the 3/8-inch notched plates, drilled them for the mounting bolt, and epoxied the shims in place in the telescope tube using the waxed base casting as a clamp.

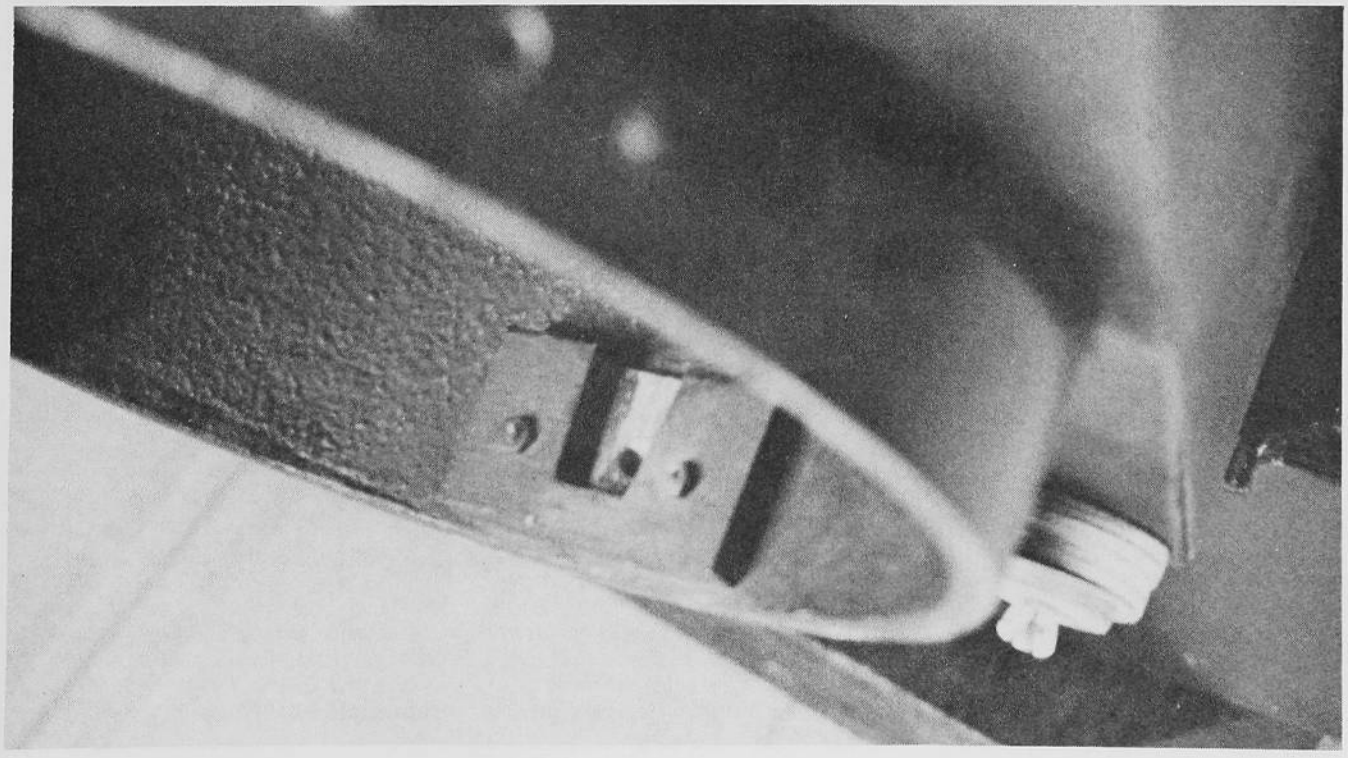
After the epoxy had set, I removed the base casting, rewaxed it, and resecured it to the tube. I then gave the notched 3/8-inch plates a liberal glob of an epoxy-sawdust mixture on the outer side of each (to fill the gap between the plate and the curve of the tube) and then epoxied the plates to the tube wall. They were clamped by two #10 bolts I had fitted previously.

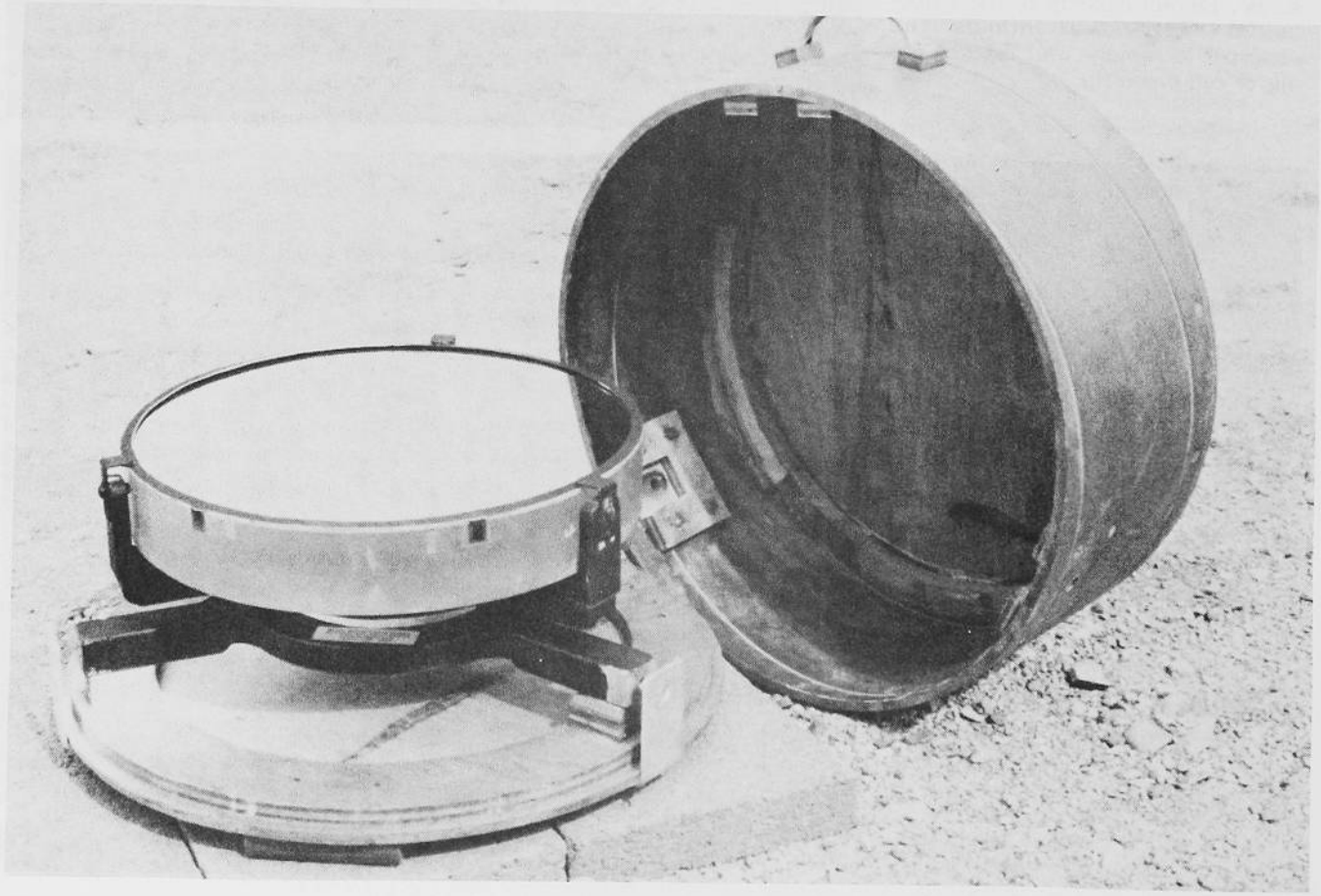
It's important that the tube is long enough for the notched plates to fit behind the tapered legs of the base casting, and there must also be enough room ahead of the cell so the cell can be pushed past the notched plates, turned so the legs line up with the notches, and then the legs can be "dropped" into the notches.

In particular, the upper edges of the notches must be beveled so as not to catch the edges of the mirror-mount legs on their way into the notches. I took care to fit the notches and to shim the thin plywood plate against the tube before epoxying, so the cell will goes in and out with a "slip fit." The slight flexure of the tube about its circumference takes care of any tendency of the cell to jam because of tilting.

"I wonder if there aren't more than a few visual observers for whom the Dobsonian mounting is revolutionary enough."

Hopelessly shaky on a now-discarded classic pipe mounting, this 12-inch f/5.6 telescope rides firmly on its Dobsonian mount. Note the low center of gravity of the telescope. Below: closeup of the trapezoidal "key" that allows the observer to remove and replace the mirror cell precisely,





"A key system allows the legs to be dropped into the same position time after time in exactly the same way."

One leg of the mount must be marked so you get the same leg into the same slot every time. With the cell's legs located positively and snugly in the tube, it takes nothing more than short thumbscrews with washers to secure the mirror cell—and thumbscrews are much handier for take down and setup than the usual hex-wrench routine.

If you want to avoid recollimation, the mirror must not be able to rotate in its cell. I found that a pad of double-sided tape on one of the edge supports prevent rotation very well: my cell has been removed and replaced in the tube numerous times without recollimation. There is no difficulty in picking an edge support that will bear the weight of the mirror both in the tube and when it's carried in the case.

I made the carrying case for the mirror cell from a section of leftover Sonotube in much the same way the lower end of the telescope tube was treated, except that tolerances were far sloppier. The base is plywood paneling the same diameter as the tube with an inner ring that fits inside the tube. The cell's legs rest on three raised blocks so that the under parts of the cell can be grasped easily. The disk of paneling that forms the upper lid is fastened last, so the work can be done through the open top of the tube section when necessary.

The cell is centered in the case by means of the same system of thin plywood shim plates and notched 3/8-inch plywood plates, epoxied in place while the base casting is used as a jig and clamp. After the cell is permanently located, the blocks are marked and trimmed to the same width as the bottoms of the cell legs that rest on them. When this is done, the cell can be centered over the blocks in the dark by the simple expedient of placing the thumb and forefinger over each leg and its block and squeezing them into alignment by feel.

The top is then carefully lowered over the mirror, which allows the tapered notches to locate the bolt holes in the case over the tapped holes in each leg. The same thumbscrews that secure the mount in the tube, secure it in its case with 1/8-inch aluminum straps that hold the two parts of the case together. I used the carrying handle to mark a bolt hole and a corresponding block on the base is marked with white paint to receive the notched leg of the mount.

I attached a carrying handle to the side of the tube section so that the mirror would be carried in an edge-up position. It is stored that way to keep dust off the face, but for safety's sake, it's transported in the case face-up.

The case is quite strong. The lid is made of old, hard 1/4-inch paneling. My ten-year-old stepson has used the empty case for an observing platform without harm to it, but the lid should probably be thicker for such uses.

The weight of the completed telescope (--is a telescope ever completed?) *sans* mirror and cell is only about 68 pounds and was kept down by building a shorter than usual box around the bottom of the tube and by placing the altitude bearings at the very top of the box. The trunion/box assembly could have been split in two and provided with hinges and trunk latches, perhaps reducing the weight of the "bare" tube to around 50 pounds or less, but I'm blessed with a sturdy co-observer in the household, and at present the telescope is only carried a few feet into the backyard for setup.

The weight of the mirror and cell helped keep the tube's balance-point near the mirror end. This seems to result in a more stable instrument than many thin-mirror jobs that teeter on too-tall rocker boxes. With an 80-inch height, the tube of the 12.5-inch f/5.6 has a center of gravity only 29 inches from the ground and 25.5 inches above the ground board.

The Dobson concept of fast, thin-mirror light buckets is as valid as ever for viewing extended deep-sky objects at low magnification. However, I wonder if there aren't more than a few other "nuts and bolts" telescope builders who, like me, find themselves allergic to the flexible optics and severe coma so common in badly built Dobsonians. There is no reason a Dobsonian should have anything but top-flight optics.

I wonder if there aren't more than a few visual observers for whom the Dobsonian *mounting* is revolutionary enough. Perhaps the many longer-focus 10-inch and 12.5-inch mirrors now gathering dust will—if properly remounted in Dobsonian mountings—once again astound us with their exquisite definition.

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Description of Johann Schröter's 27-foot Newtonian Telescope built at Lilienthal —1793—

According to Henry C. King in his well-known *The History of the Telescope*, Johann Hieronymous Schröter was the bailiff of Lilienthal, a small town near Hanover in Germany. He bought his first telescopes—4-foot and 7-foot reflectors—from William Herschel and actually used them for celestial observations. He worked his way up to a 13-footer of 9.5 inches aperture, then set out to build his own very large telescope—a 27-footer of 18.5 inches aperture.

Schröter used the telescope to observe Venus, and concluded from his observations that the planet had a highly mountainous surface. (King notes that Herschel did not agree with Schröter's conclusions.) The description of his telescope, constructed in 1793, appears in Schröter's *Aphroditographische Fragmente* (1796). (Robert Burnham brought the book to my attention. The telescope description was translated from the original German by Eleanor Berry and Robert Burnham. Thanks to both of them.)

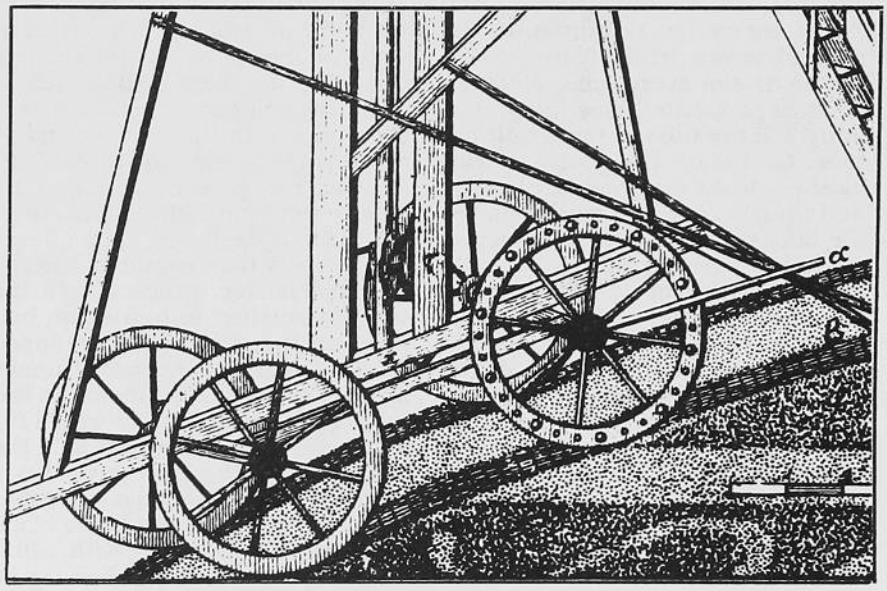
Schröter also wrote a classic of lunar study, *Selenotopographische Fragmente*, and in his astronomical studies was closely involved with Olbers (discoverer of Pallas), Piazzi (discoverer of Ceres), Harding (his assistant, and the discoverer of Juno and Vesta), and Gauss, the famed celestial mechanician. In 1813, the French army sacked and burned Lilienthal, and Schröter saw his home and the 27-foot telescope pillaged. He died three years later and the remains of the observatory was demolished.

The 27-foot telescope was used in the open air, and was apparently quite functional. As you study the large copperplate drawing, keep in mind the huge scale of this telescope. Despite the inaccurate perspective in the drawing and the convoluted wording (not altogether absent in the translation) of the instrument's description, it is nonetheless possible to gain a good sense of how this large telescope, very similar to Herschel's 20-foot telescopes in its aperture, would have been used.

The copperplate is reproduced at its original size on the next spread; the closeups are reproduced at twice the original scale.

My comments on the instrument appear in italics.

-- Richard Berry



Telescopium Newtonianum XXVII pedum, constructum Lilienthalii—1793

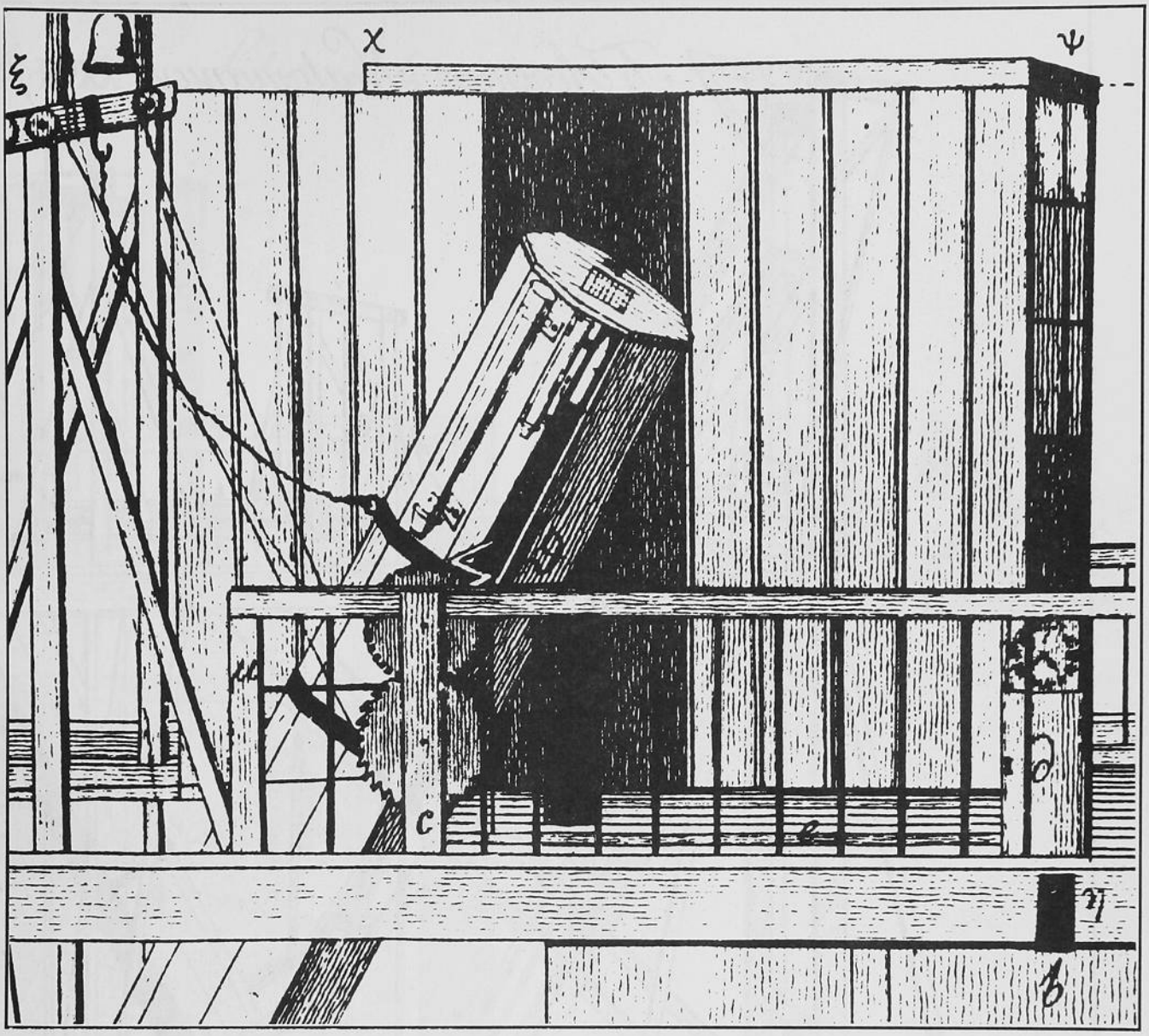
a. The telescope support, a strong tower. *(Note the half-timber construction!)*

b. Within this casing, a pivot, on which the tower's gallery is rotated.

c, d. The tower's gallery, at c the telescope's main winch, whereby the back part of the telescope is wound up and let down by means of a pulley.

d. A strong, solid pier, erected right through the tower and the gallery, around which the gallery with the telescope is turned. Upon it, an astronomical pendulum-clock.

e. The gallery's bent beam, on which the telescope is fastened by means of its manual drive. *(The term "bent*



beam" is Krummbalken in the German. We're not sure what it means.)

f, g. Two horizontal beams, which drive the rotating gallery, together with the telescope, around the pier and clock d.

h, i. Two posts connected therewith, resting on a cart below.

h, i. Located on these and on the drive beams, a little gallery for alignment of the mirror, reached by means of a hanging stairs (ψψ). *(This is mislabeled as αα in the copperplate.)*

k, l. Two angle beams set up behind the circle of movement of the tube, between which the back part of the tube is wound up and down by means of the winch c.

m, n. Two diagonal tie-beams to the support structure.

o, p, q, r, s, t. Six secondary tie-beams to the support structure.

u, v. A frame that is wound up between the two angle beams k, l, upon which the back part of the tube rests on a roller v. *(The frame moves along slots in beams k and l.)*

w. The pulley of eight sheaves, whereby the required inclination is given to the tube by means of the winch c located on the gallery. *(This presumably afforded either fine control or large mechanical advantage, or both.)*

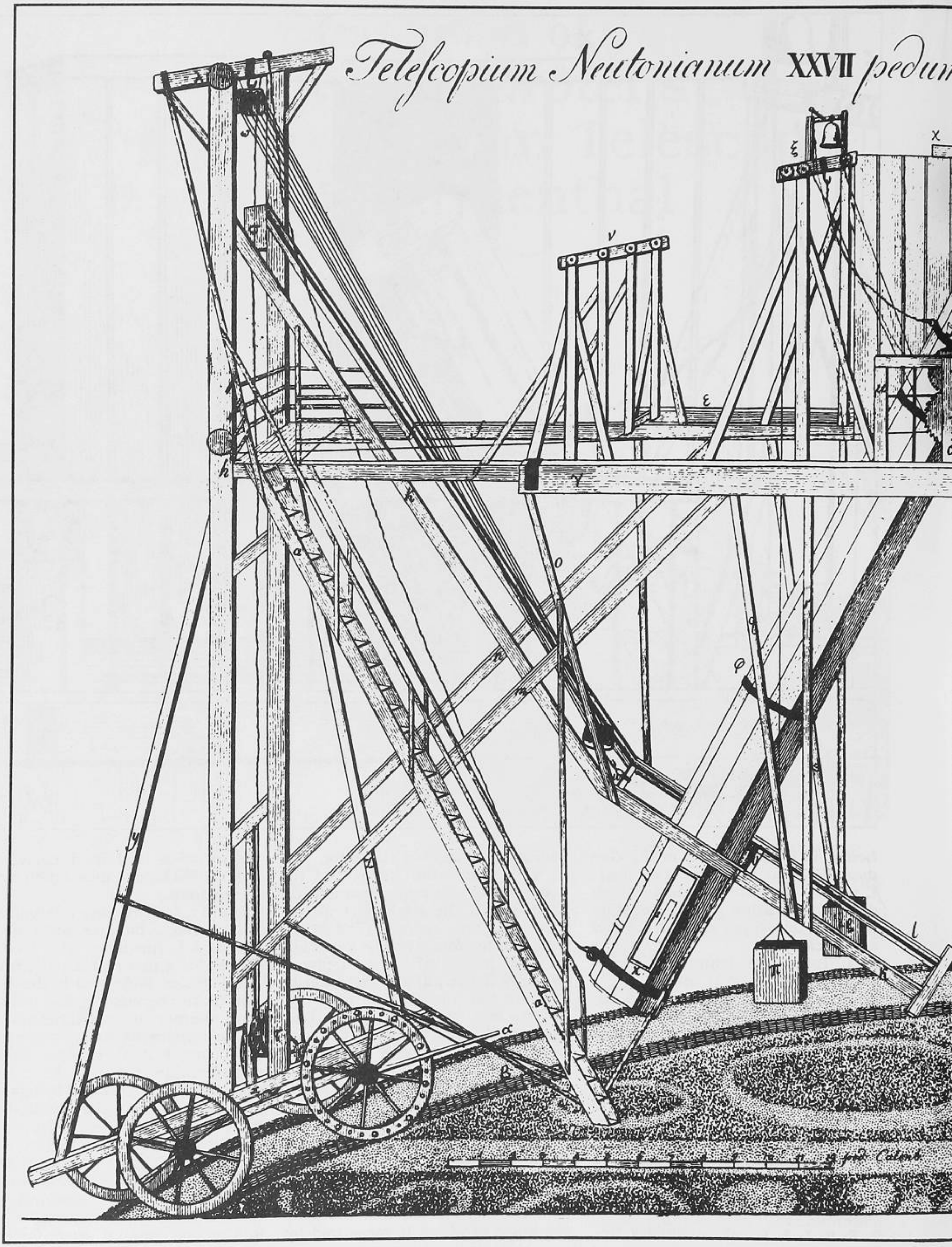
x. The cart, by means of which the tube and the gallery are driven around the tower's pier and clock, and the azimuthal direction is given to the telescope.

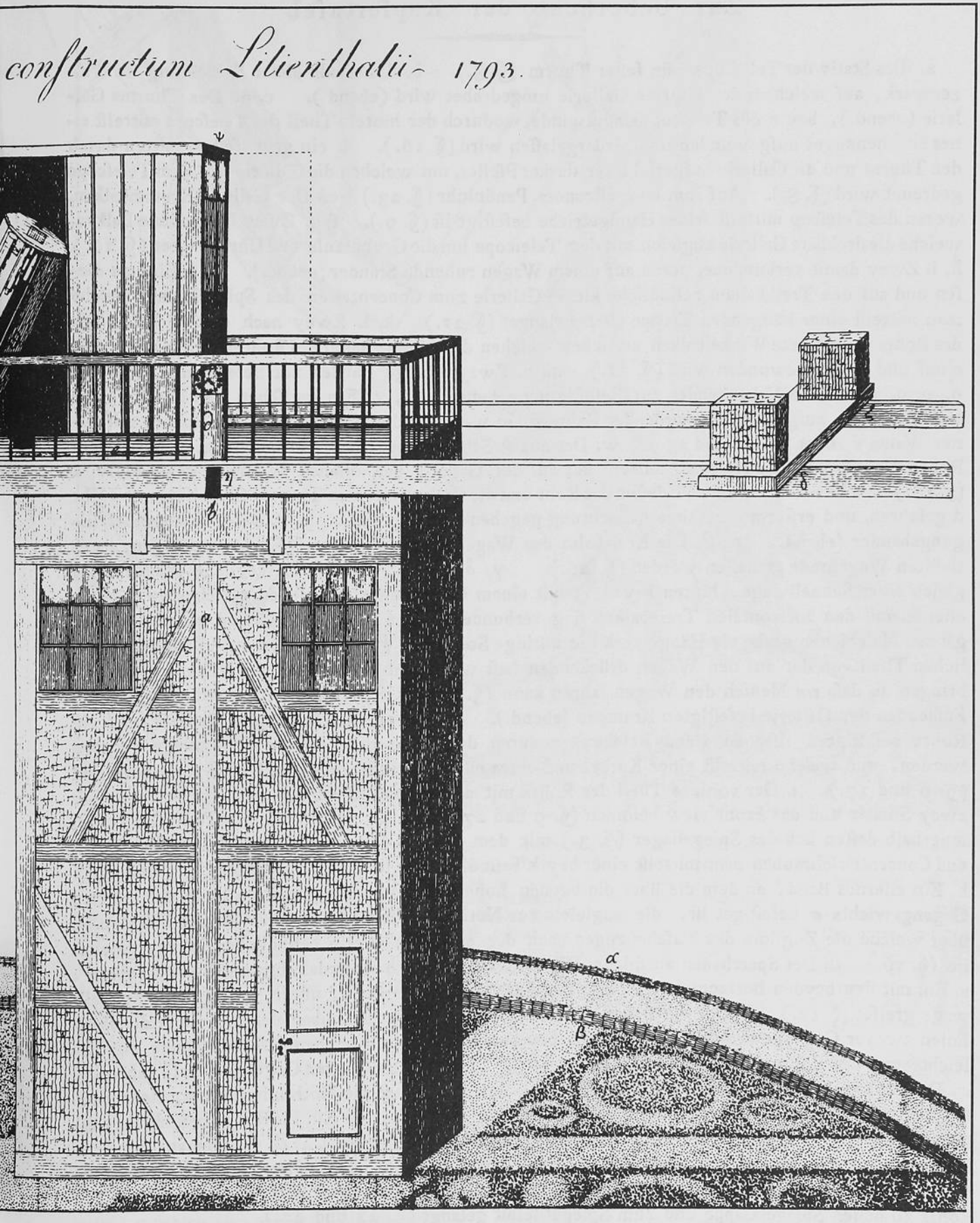
y, z. Two diagonal tie-beams to the support structure.

α, β. The circular track of the cart, the angle of which is measured by means of a sectioned cartwheel. *(The marks on one wheel may measure degrees.)*

γ, δ and ε, ζ. Two moveable balance beams, like a balance scale, in the rear at δ, ζ, furnished with a counterweight, which presses at γ under iron staples joined with the horizontal drive beams f, g, and not only gives the necessary stiffness to the whole apparatus as a suspension structure, but also takes away a considerable part of the weight pressing on the cart and brings it to the middle of the gallery, so that <u>one</u> man can drive the cart. They rest at η on iron staples fastened into the floor of the gallery. *(What a clever guy! "Balance scale" is Schnellwage in the German. "Steelyard" is another possible translation.)*

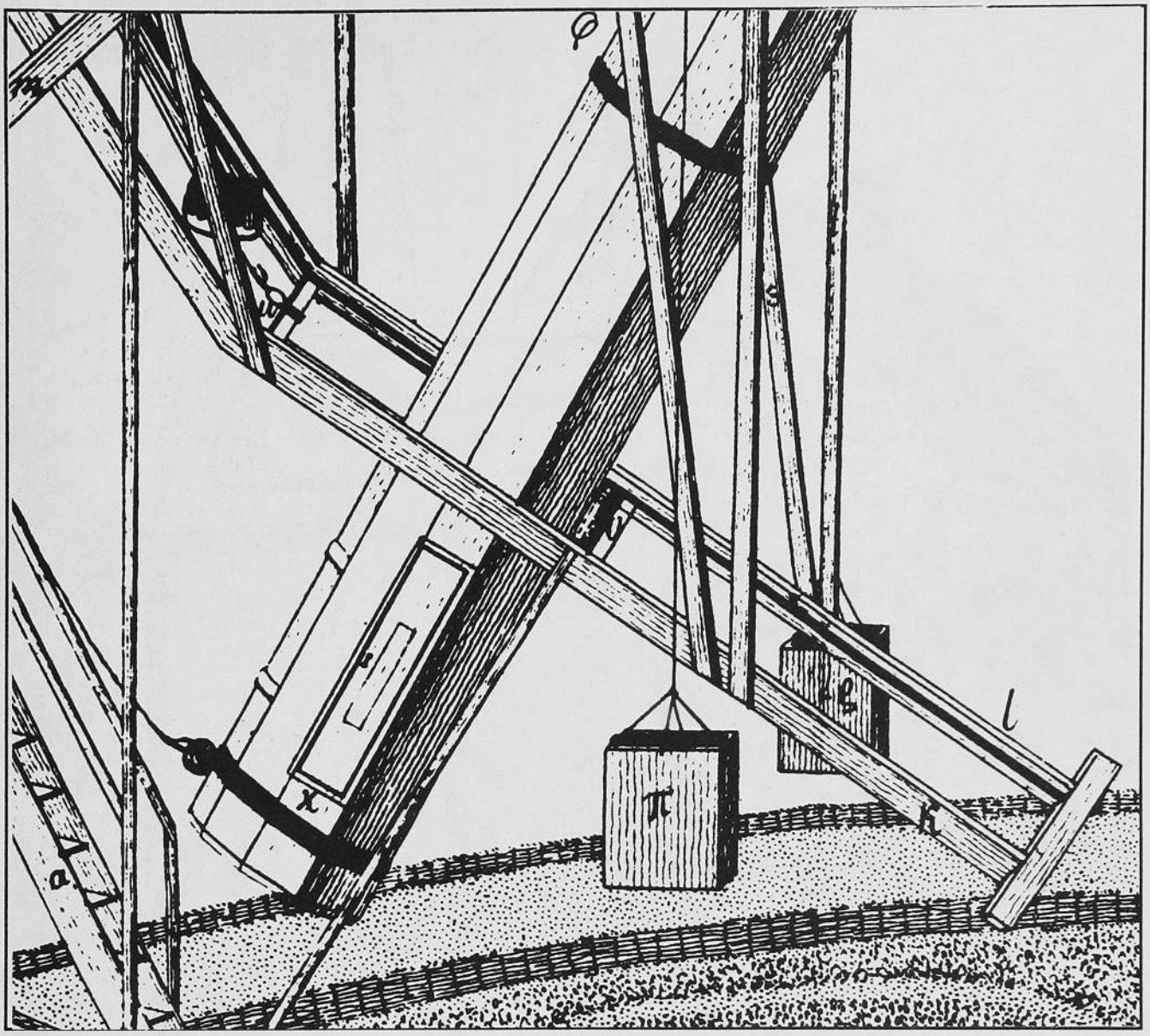
θ. The iron manual drive, fastened


Telescopium Neutonianum XXVII pedum
12 ped. Calenb.


constructum Lilienthalii 1793.

Zur Ueberſicht der Kupfertafel.

a. Das Stativ des Teleſcops, ein feſter Thurm (§. 8.). b. Innerhalb dieſer Bekleidung ein Walzenwerk, auf welchem des Thurms Gallerie umgedrehet wird (ebend.). c, d. Des Thurms Gallerie (ebend.), bey c des Teleſcops Hauptwinde, wodurch der hintere Theil des Teleſcops mittelſt eines Flaſchenzuges aufgewunden und niedergelaſſen wird (§. 16.). d. ein grundfeſter, mitten durch den Thurm und die Gallerie aufgerichteter ſtarker Pfeiler, um welchen die Gallerie mit dem Teleſcope gedrehet wird (§. 8.). Auf ihm eine aſtronom. Penduluhr (§. 23.) e. Der Gallerie Krummbalken, woran das Teleſcop mittelſt ſeiner Handgetriebe befeſtigt iſt (§. 9.). f, g. Zwey horizontale Balken, welche die drehbare Gallerie zugleich mit dem Teleſcope um die Grundſäule und Uhr d treiben (§. 10.). h, i. Zwey damit verbundene, unten auf einem Wagen ruhende Ständer (ebend.). h, i. Eine an dieſen und auf den Treibbalken befindliche kleine Gallerie zum Concentriren des Spiegels, auf welche man mittelſt einer hängenden Treppe $\psi\psi$ gelanget (§. 21.). k, l. Zwey nach dem Cirkelſchlage des Rohres gerichtete Winkelbalken, zwiſchen welchen der hintere Theil des Rohres durch die Winde c auf und nieder gewunden wird (§. 11.). m, n. Zwey ſchräge Bänder zur Befeſtigung (ebend.). o, p, q, r, s, t. 6 Nebenbänder zur Befeſtigung (ebend.). u, v. Ein zwiſchen den beyden Winkelbalken k, l, aufgewunden werdender Rahmen, in welchem der hintere Theil des Rohres auf einer Walze v ruhet (§. 11 und 15.). w. Der aus 8 Scheiben beſtehende Flaſchenzug, wodurch dem Rohre die erforderliche Neigung mittelſt der auf der Gallerie befindlichen Winde c gegeben wird (§. 16.). x. Der Wagen, mittelſt deſſen das Rohr und die Gallerie um des Thurms Grundſäule und Uhr d gefahren, und erſterm die Azimethalrichtung gegeben wird (§. 12.). y, z. Zwey ſchräge Befeſtigungsbänder (ebend.). α, β. Die Kreisbahn des Wagens (ebend.), deren Grade von einem abgetheilten Wagenrade gemeſſen werden (§. 26.). γ, δ und ε, ζ. Zwey bewegliche Wagebalken, gleich einer Schnellwage, hinten bey δ, ζ, mit einem Gegengewicht verſehen, welche bey γ unter eiſerne, mit den horizontalen Treibbalken f, g verbundene Krampen drücken, und nicht nur dem ganzen Maſchienenwerke als Hängewerk die nöthige Steifigkeit geben, ſondern auch einen beträchtlichen Theil von der auf den Wagen drückenden Laſt wegheben und ſie auf die Mitte der Gallerie bringen, ſo daſs *ein* Menſch den Wagen fahren kann (§. 13.). Sie ruhen bey η auf eiſernen, im Fuſsboden der Gallerie befeſtigten Krampen (ebend.). ϑ. Die am Fuſsboden der Gallerie und am Rohre befeſtigten eiſernen Handgetriebe, wodurch dem Rohre die feinern Richtungen gegeben werden, und welche mittelſt einer Kurbel und eines eiſernen Bandes mit dem Rohre verbunden ſind (§. 9 und 17.). ι. Der vordere Theil des Rohrs mit der vordern Oeffnung und Klappe, wo ſich zwey Sucher und das Front view befinden (§. 9 und 27 bis 29.). $\varkappa$. Der hintere Theil des Rohrs, innerhalb deſſen ſich das Spiegellager (§. 3.) mit dem Spiegel (§. 1.) befindet, zu deſſen Kapſel und Concentrirſchrauben man mittelſt einer bey k befindlichen Seitenklappe gelanget (§. 5 und 15.). λ. Ein eiſernes Band, an dem die über die beyden hohen Wagenſtänder geleitete Linie des hintern Gegengewichts σ befeſtiget iſt, die zugleich zur Nothlinie dienet (§. 19.). λ. Die Seitenrolle, über welche die Zuglinie des Flaſchenzuges nach der auf der Gallerie befindlichen Winde geleitet iſt. (§. 16.) μ. Der Sperrhaken an ſolcher Winde, welcher durch ein Pedal abgezogen wird (ebend.). ν. Ein mit den beyden horizontalen Treibbalken feſt verbundener Bock, unter welchen die Schnellwage greifet (§ 13.). ξ. Der vordere Bock mit der Bedientenglocke, über deſſen Rollen die Zuglinien zweyer Gegengewichte π, ϱ nach dem bey μ am Rohre befindlichen eiſernen Bande zur Erleichterung des Rohrs geleitet ſind (§. 18.). π, ϱ. Die daran befeſtigten Gegengewichte (ebend.). σ. Das hintere Gegengewicht des Rohrs (§. 19.) Von ihm gehet die Nothlinie nach τ, einer zwiſchen den Wagenſtändern befindlichen zweyten Winde (ebend.). φ. Ein im Rohre befindliches eiſernes Band mit Krampen, zum Aufziehen des Rohrs beſtimmt (ebend.). χ, ψ. Ein auf der Gallerie angelegtes bequemes Schreibcabinet (§. 25.). Ein zweytes iſt im Thurme bey a vorgerichtet (§. 24.). ψ, ψ. Eine bequeme hängende Treppe, auf welcher man unter allen Neigungen des Rohrs zu deſſen Spiegelklappe und zum Spiegel ſelbſt gelangt (§. 21 und 22.).



onto the floor of the gallery and onto the tube, whereby the fine motions are given to the tube, and which is connected with the tube by means of a crank and an iron band. *(The plate shows no detail whatsoever. This device presumably gave fine motions in both axes.)*

ι. The front part of the tube with the front opening and hatch, where two finders and the front view are located. *(Schröter used the telescope in the Herschelian, or "front view" manner.)*

κ. The back part of the tube, within which is located the mirror cell with the mirror, the case and alignment screws of which are reached by means of a side hatch at κ.

κ. An iron band, on which is fastened the cord of the back counterweight σ (which also serves as the emergency line), drawn over the two tall cart posts. *(There are two safety lines, one at the front and one at the back of the telescope. They are shown as slack in the copperplate.)*

λ. The side roller, over which the draw line of the pulley is conducted to the winch located on the gallery. *(The line also passes over a second pulley just above the letter h in the copperplate.)*

μ. The catch on this winch, which is taken off by means of a pedal.

ν. A lifting jack firmly connected with the two horizontal drive beams, under which the balance scale catches. *(The purpose of this jack is not clear to me.)*

ξ. The front lifting jack with the servants' bell, over the rollers of which the draw lines of two counterweights π, ρ are conducted to the iron band located on the tube at μ to lighten the tube.

π, ρ. The counterweights fastened thereon.

σ. The back counterweight of the tube. From it the emergency line goes to τ, a second winch located between the cart posts. *(This winch is very crudely drawn.)*

φ. An iron band with staples located on the tube, designated for pulling up the tube.

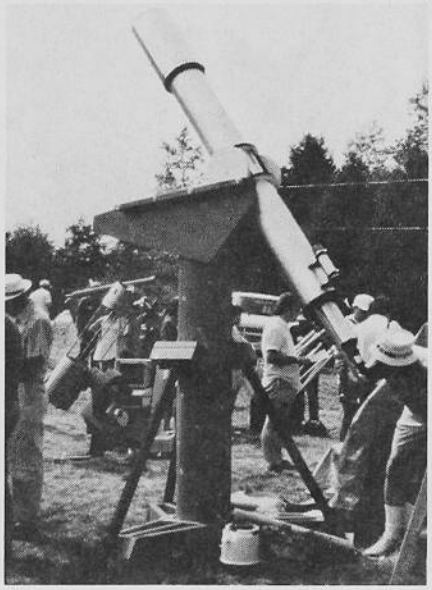
χ, ψ. A convenient writing room placed on the gallery. A second one is set up in the tower at a. *(It even has lace curtains in its windows!)*

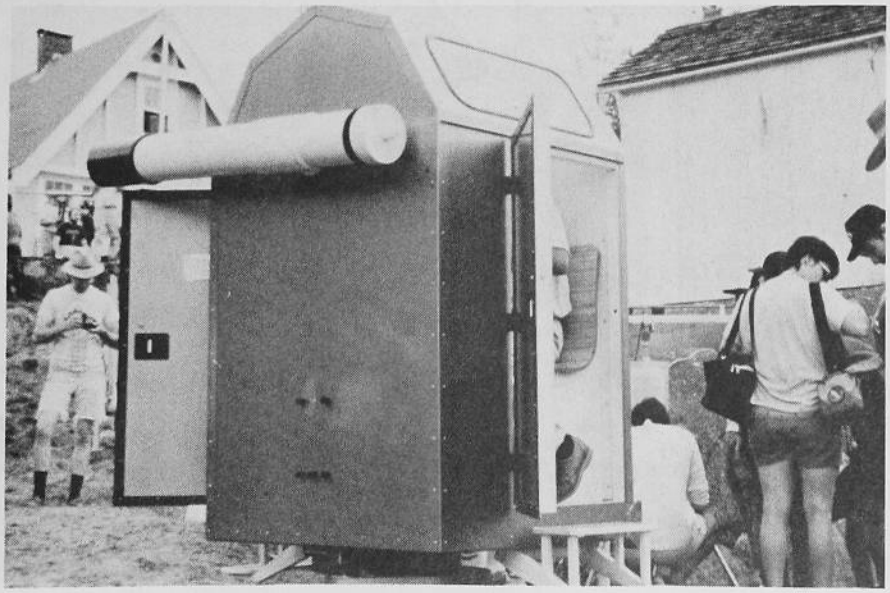
ψ, ψ. A convenient hanging stairs, by which one can reach the mirror cell and the mirror itself at all inclinations of the tube. *(The stairs are mislabeled as α, α.)*

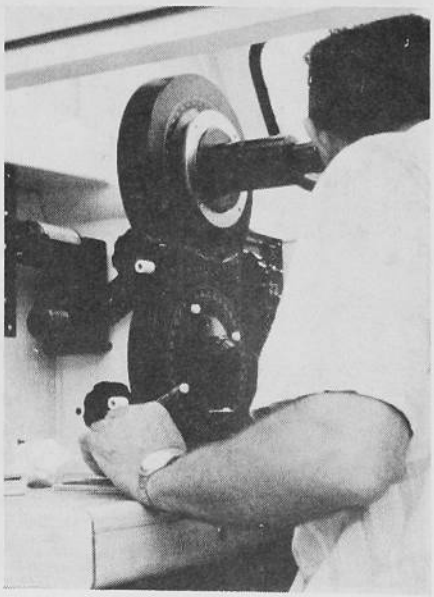
Stellafane

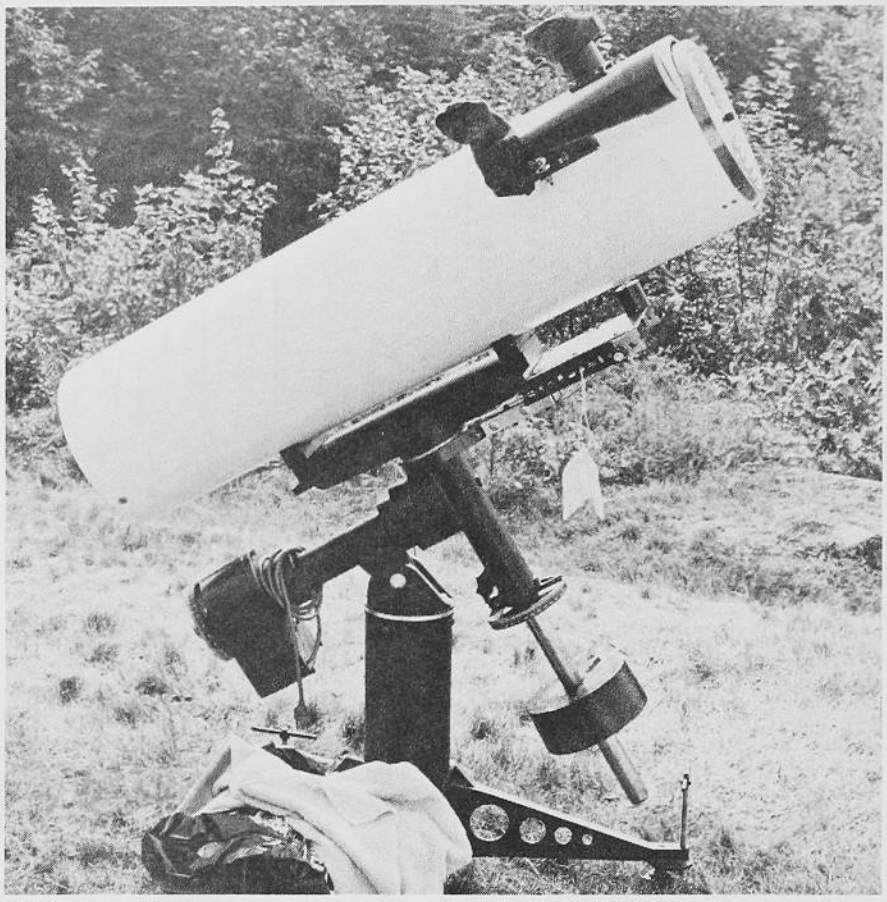
A Big Year for Alt-Az Refractors

Opposite page: Bill Volna's transportable observatory was the show stopper at this year's Stellafane convention, held at Springfield, Vermont, August 12-13, 1988. Inside the "tractor cab," observers sit and comfortably observe using a 6-inch refractor.Below and right: Susan French's photos show the doors open, and an observer at the eyepiece . Far right: Larry Manuel's 81mm Dobsonian refractor utilizes a design from Build Your Own Telescope. Right: Alan and Sue French's 8-inch f/11 Christen refractor gave stunning views of the Sun. Susan French photo.



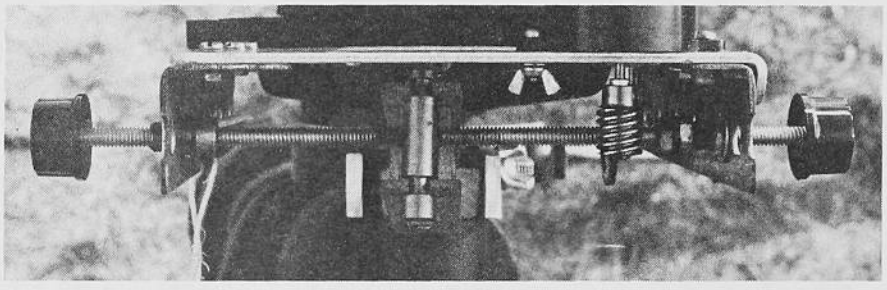


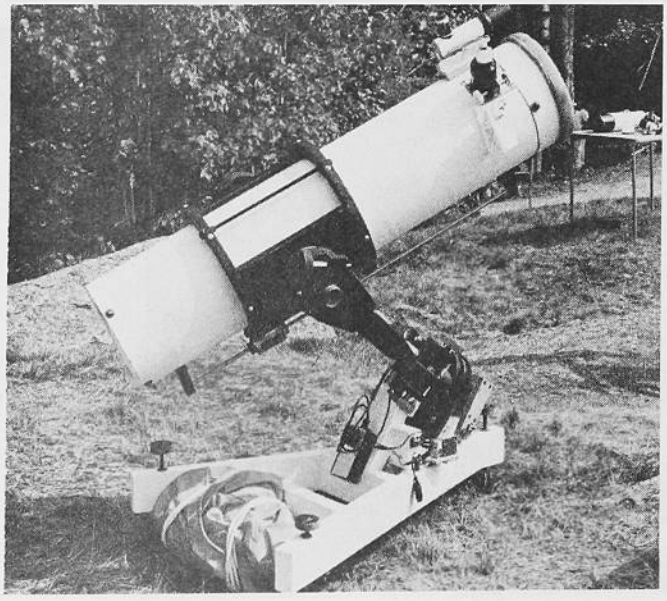


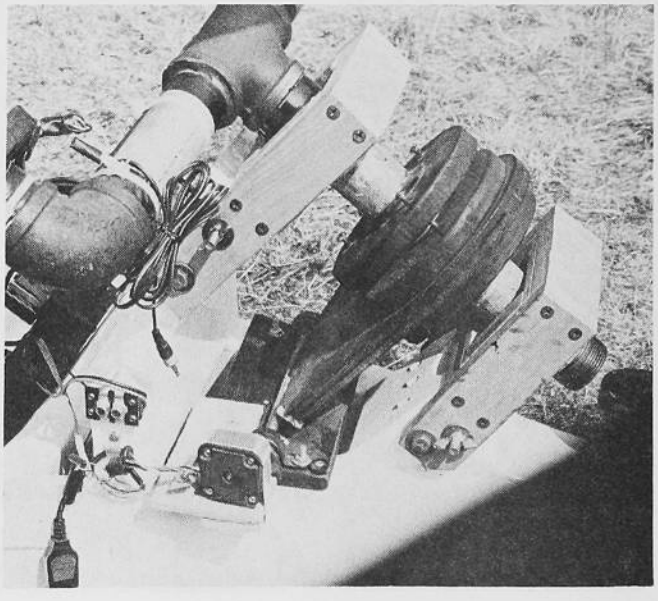


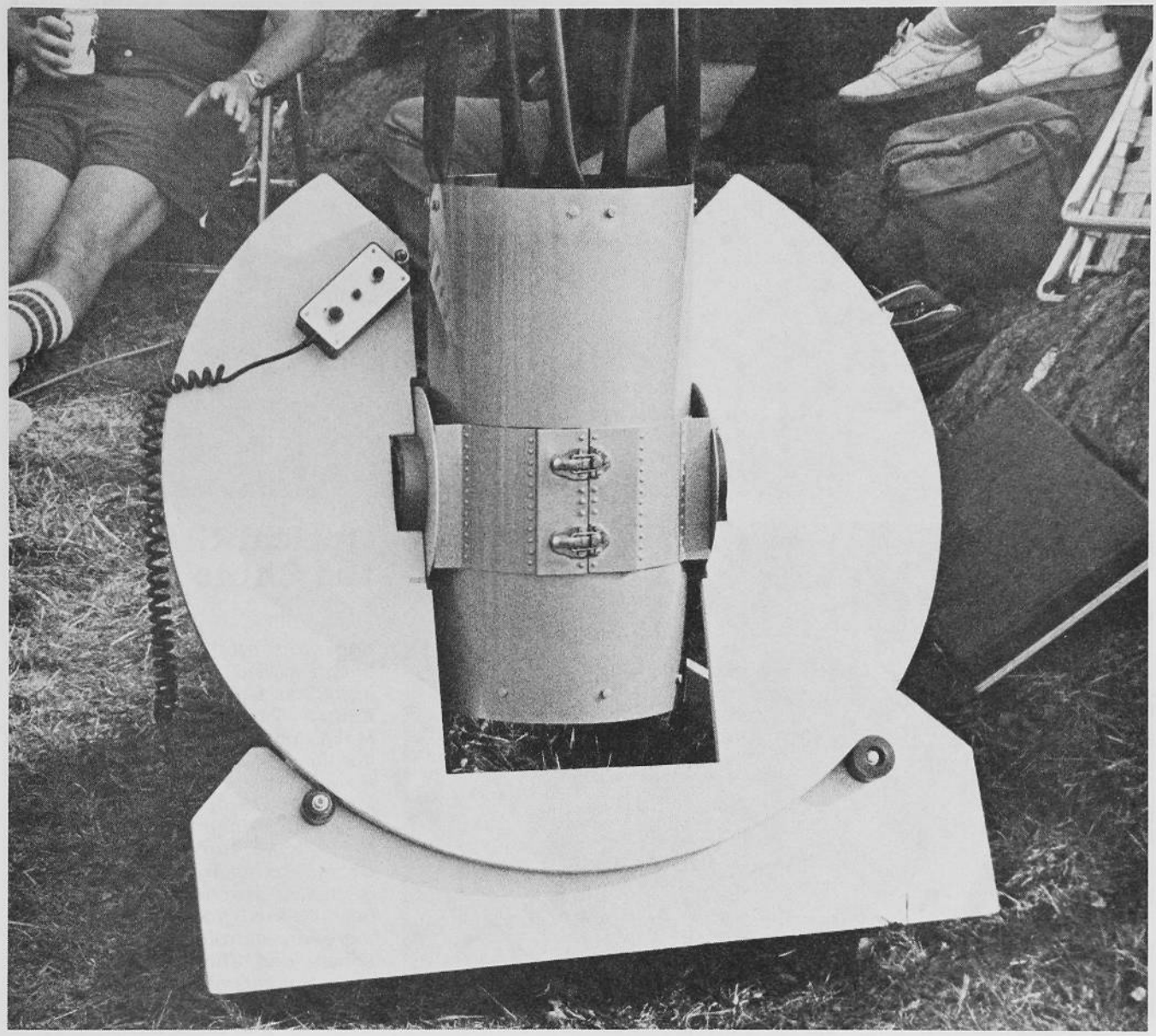
Big & Small Newts

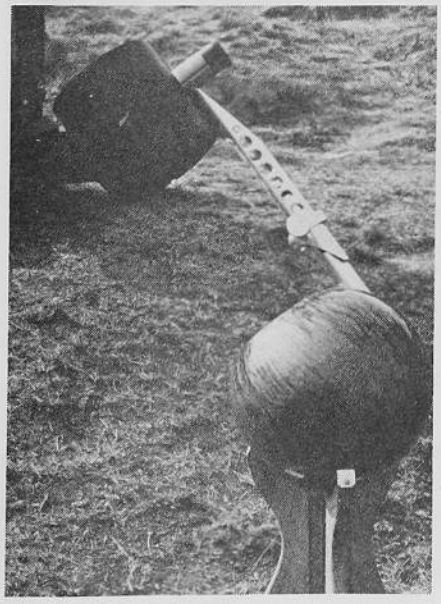
Above: With help from Dad, five-year-old Brendan Hirtle ground his own 4.25-inch mirror for a bowling ball telescope. The telescope is shown below, right, Left and below left: Thomas Massey's sturdy 10-inch f/5 Newtonian, used a curved bolt for its declination slow motion. Bottom left and below: Andre Germain of Montreal brought an 8-inch f/5.5 fork-mounted Newtonian crafted from surplus pipe fittings. Note the wooden drive gear. Far right, below: aluminum and wood fork mount by Mike O'Connell holds a 17.5-inch f/4.5 scope; guy wires stiffen the tube. Right: Kent Rothermel brought a beautiful polar-disk mounted 10-inch f/5.6 Newtonian from Ohio.

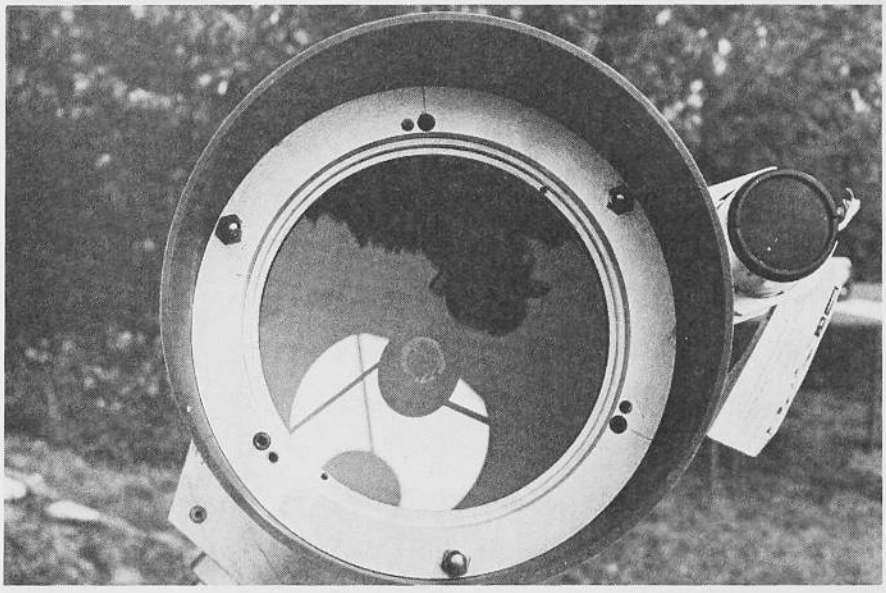








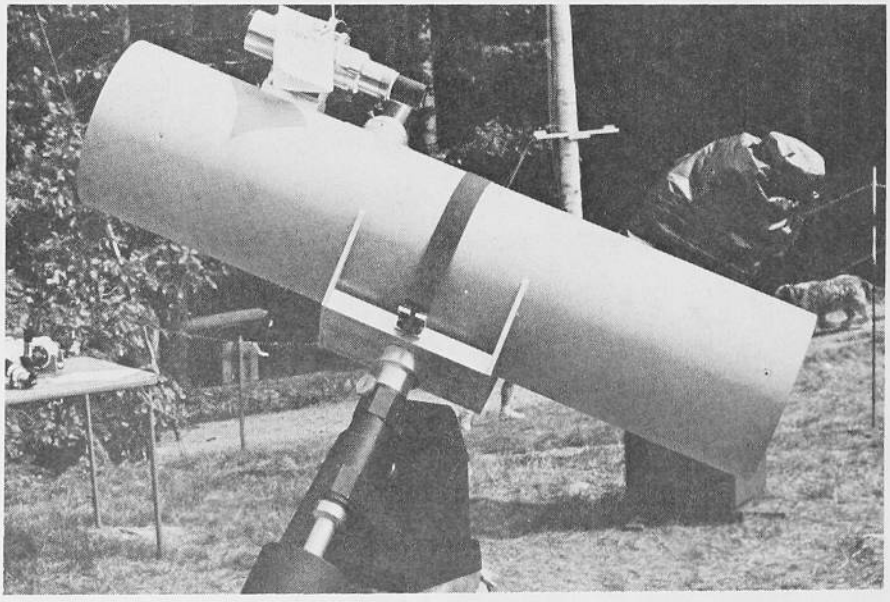


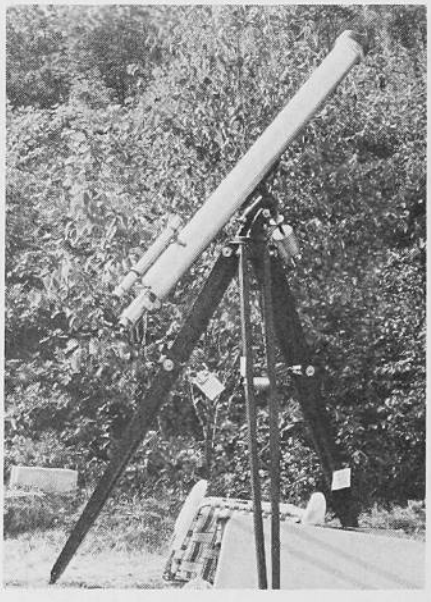


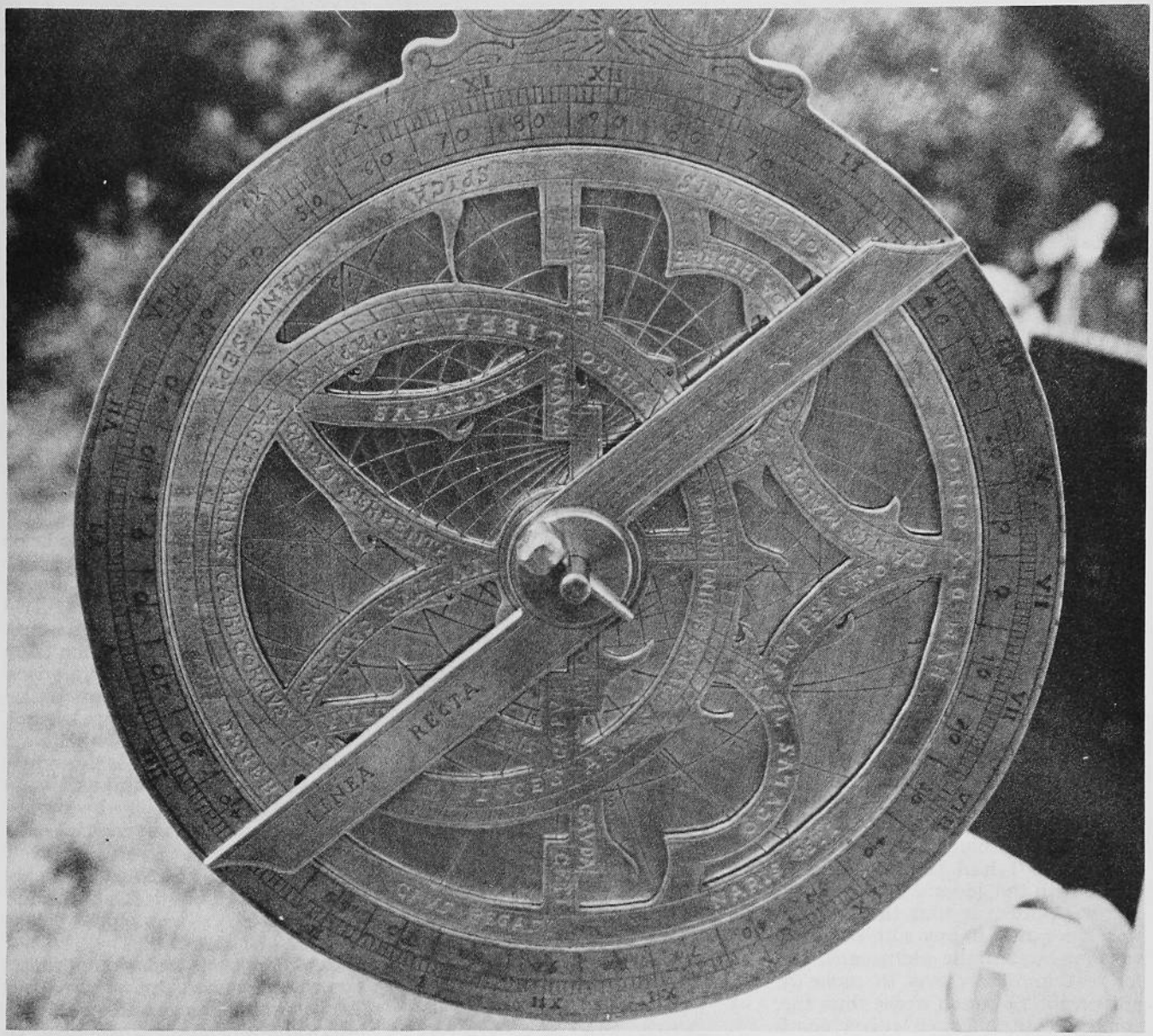
Optical Glass and the Shine of Brass

Saturday afternoon Clyde Tombaugh signed posters as admirers looked on. Left and below left: Dave Kelly's 6-inch f/4.5 Newtonian-Maksutov used simple parts elegantly machined from aluminum. Below: Norbert Vance of Allen Park, Michigan displayed a beautifully restored 4-inch Clark refractor. Below right, far right, and right: George Tremberger shows replicas of ancient astronomical instruments he machined from brass. Included were an astrolabe, an armillary sphere, and "Third and Fourth Planetary Spheres of Eudoxus."

—Dave Eicher



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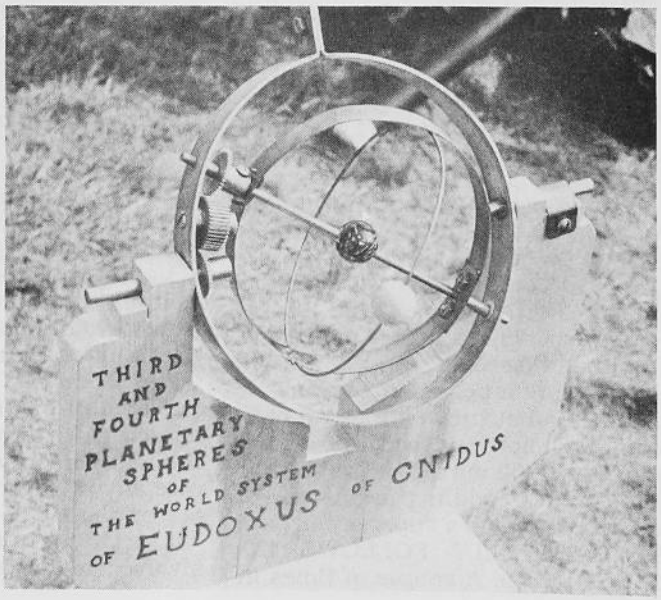

THIRD AND FOURTH PLANETARY SPHERES OF THE WORLD SYSTEM OF EUDOXUS OF CNIDUS

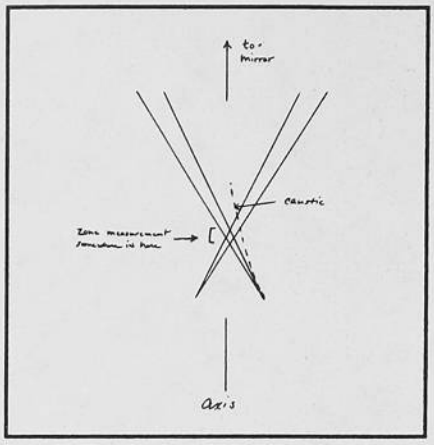
Letters

they used one set of masks. It depends on how dark you demand a zone to get for it to be judged to have the proper light intensity. Texereau's instruction to take readings where the zone is just barely tinged is probably some shop wisdom designed to minimize this error, although I am not sure. I demanded a somewhat grayer zone and probably found my balance points a little far from the mirror. Consequently I consistently made undercorrected fast mirrors.

I've made some crude calculations of this effect using my program MIRROR and found that for a typical Coulder screen, an 8-inch f/4 mirror could be 1/2 wave undercorrected if you test the mirror at the far edge of the overlap line for the outermost zone and the error goes quadratically with zone results. This is a rather extremal case, however. I'll bet 1/4-wave mirrors are regularly generated using this method, though. The star test or an alternate test method without this systematic error is crucial for fast mirrors.

To give you some background, let me describe my own experience when I made my first mirror ten years ago. I had become experienced with the general level of commercial optics at that time, and I was ignorantly happy with it. I was working essentially alone, and my fondest ambition was to make a mirror not too much worse than the commercial telescopes with which I had become familiar. I thought I had set my sights realistically low; I had only read Texereau and I had never seen a mirror completed. There were some other mirror makers in town, but we were not interacting well as a group and I learned little from them. Thus, a lone worker description fit me well. Imagine my surprise to find that my first mirror was the best one I had ever seen.

Please note that my work on this mirror didn't represent the fussing of an experienced mirror maker but the fumbling efforts and downright guessing of a beginner. I harbor no illusions about my skill as an optician. I am not very good. The quality of commercial mirrors is just so bad that even a toddling infant mirror maker can make a superior mirror if he CAREFULLY FOLLOWS INSTRUCTIONS. A couple of times in



my life I have seen the work of a really good mirror maker. I hope everyone can have this experience at least once. You step back from the eyepiece and say "So that's what it's supposed to look like." The other thing that happens is that you have the urge to roll up a newspaper, find a commercial manufacturer, and whip him till he yelps.

Dick Suiter
425 East 19th Avenue #108
Panama City, FL 32405

—My own first mirror—a rather lumpy 6-inch f/7 with a fairly bad turned-down edge—serves as the standard of performance I apply to commercial telescopes. I figure that an 8-inch aperture $2,000 Schmidt Cassegrain telescope ought to outperform a first mirror made by a thirteen-year-old junior high school student; it distresses me that my mirror still gives a better image than some of the Halley-era SCTs I've seen.

— RLB

Get Your Noses Back in Joint

Dear Richard/ I have been following the apo controversy with interest and am amazed at how easily some people get their noses out of joint. In particular, I am referring to Mike Jones' letter in *TM#33*. Rather than pick it apart paragraph by paragraph, I would just like to point out that the problem seems to consist mostly of one person misunderstanding the aims of another. When Roland Christen speaks of the "worthwhile" optical systems, he is speaking of those that are worthwhile from his perspective as a manufacturer. I'm sure from speaking to him that Roland is just about the last person who would discourage an avid ATM from trying an exotic or difficult design.

It seems to me that many of those involved in heated discussions on this subject are really talking at cross-purposes. Those who pursue the quest for the perfect optical systems obviously must make different choices than manufacturers. Even amateurs must make choices with regards to affordability, portability, and just plain talent. If each ATM would cut the next a little slack by attempting to understand how he's coming at the problem, the controversy might abate a little.

Susan French
205A Washout Road
Scotia, NY 12302

Anyone Making Schief Optics?

Mr. Richard Berry/ I am a very amateur, amateur astronomer who got the bug about a year ago when I built my first telescope: a 6-inch f/8 reflector. Since then I have had plans for a bigger telescope and have subscribed to your periodical, purchased your book, and have gotten back issues of *TM*.

The articles on the Kutter Tri-Schiefspiegler were the most intriguing, and I said, "This is the telescope I want!" But a problem arises here. All the articles mention the making of optics and this is where I get a little disheartened. I believe I would be willing and able if need be to do my own optics, but I was wondering if you know if the optics needed for such a task can be readily purchased and where?

Dwight D. Fields
219 South Elliott Avenue
Azusa, CA 91702

— You're in luck—a new outfit called Lorraine Precision Optics is making Tri-Schiefspiegler optics sets for prices that are fairly reasonable. At present, this is the only company that makes such optics that I know of. (If TM's readers know of anyone else, please let me know!) Good luck with the project—and let us know how it turns out. —RLB

Let's Test the Ronchi Test

Dear Richard/ My letter on the Ronchi star test in *TM#33* generated more interest than I anticipated. I enclose a computer-generated "Ronchigram" which shows the extent of curvature of a Ronchi band due to 1/4-wave *wavefront* deformation near the focus. The readers should decide if this much curvature can be judged "questionable" or "subjective," as one correspondent wrote.

My only question is not whether this method is capable of showing 1/4-wave error, but rather, what is

Editorial

WARNING: Optical fabrication can be hazardous to your health. Opticians who work with diamond generating equipment may contract emphysema from inhaling the fine mist of glass, water, and oil these machines throw off. Optical materials themselves may be poisonous and pose a hazard.

The good news is that amateur optical workers are perfectly safe. The bad news is that professional opticians are often at high risk and may not even be aware of it.

The most unfortunate case I know of was that of a young amateur telescope maker turned professional who took a position at a large observatory as an optical technician. In special types of instruments, exotic materials are often used to reflect or refract radiation other than visible light. This technician was asked to make some special optics from one of these materials. He did not know that special precautions had to be taken when working this material and that it was especially important to have the work area adequately ventilated. To keep the shop at the right temperature for his polishing laps, he sealed off the ventilation. As a consequence he inhaled the residue produced by working the material and died a short time later.

While I was working in a professional optical shop in the Boston area in the late 1950s, I was asked to work two exotic optical materials. One material used at the time for infrared work contained arsenic. As soon as I finished working the material, I scoured my hands with a stiff brush, especially under the nails, at least three times to remove any contamination. I don't even remember now the name of a second material was, but I was warned to take special cleaning steps. If it got into your system, I was told, it wouldn't bother you then but would kill you twenty years later (sort of an optical Russian roulette!). I practically rubbed the skin off my hands when through working it.

Fortunately amateur telescope makers aren't at risk. Fabricating optics with grits of aluminum oxide and silicon carbide abrasives and rare-earth polishing compounds like cerium oxide mixed with water to grind and polish glass is perfectly safe. None of these compounds is poisonous, no dangerous residues are released, and hand grinding does not throw aerosols into the air that can be breathed.

For professionals it's a different matter. In professional shops, grinding and polishing slurries are machine-fed from reservoirs in the machine or worked under water in a solution that has the grinding or polishing compound suspended in it. High-speed machines spray these materials into the surrounding air and thence into the lungs of the optician. Workers can encounter hazardous working conditions, one in which the final result is emphysema -- a serious and incurable disease.

Diamond cutting and surfacing equipment is widely used in professional shops. Fine diamond powder is carried in a metal disk used for cutting. To cool and lubricate the grinding surface, a special cutting oil is mixed with water. When the surface is curved, one tilts the diamond wheel at an angle, and when correctly positioned, it will curve the surface to the desired accuracy very rapidly.

The high-speed action throws a spray of water, oil, and finely powdered glass into the air around the machine. Breathing this mist causes emphysema if one is exposed to it long enough. Finely powdered glass and silica list just below asbestos as potent causes of emphysema. Other causes of emphysema are cigarette smoking, coal dust (which causes the black lung disease of coal miners), and the mixture of deadly agricultural chemicals and dust encountered by farmers.

I have seen diamond cutting wheels in many optical shops run with this spray escaping into the surrounding air. Even when machines are enclosed in plastic or metal covers, when the run is completed, or the machine is shut down, the operator opens a door and sticks his head and arms in to check the work. The fine mist that hangs suspended inside the machine is the most dangerous to inhale. It contains the very fine glass particles that attack the lungs most severely.

At no time have I seen any optician wear a mask that covers the nose and mouth for protection while checking a diamond generating machine, and I can only conclude that most optical workers are unaware of the danger. Therefore, I urge everyone who works with such equipment and everyone who knows someone who works with such equipment to take proper precautions. Wear a face mask around diamond surfacing machines unless they have been turned off long enough to allow any dangerous mists to settle.

I would also advise anyone who has worked unprotected around such machines for any length of time to obtain a pulmonary check of his or her lungs to be sure he or she hasn't contacted emphysema. This disease cannot be reversed. Once the cells of the lungs are damaged, they are gone forever. The sooner you discover this condition, the better chance you will have of keeping it under control for an extended period of time with modern respiratory therapy.

Since my retirement in 1982, I have been out of professional optical shops. Nonetheless, I urge those who work in shops that use diamond cutting equipment to contact OSHA. Find out whether OSHA is familiar with this situation and has issued any guidelines. If OSHA is unaware of the hazards, it should examine the situation and issue guidelines to protect the health of optical workers.

-- Robert E. Cox

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the error when the bands appear perfectly straight? One thing is certain: when the bands appear free of any curvature, the wavefront is decidedly better than 1/4 wave.

If anybody out there is making 6-inch f/13.3 Newtonian — a cheap alternative to an apo — test it at the focus before you parabolize it, and then let us know if you could see the 1/4-wave wavefront error with a Ronchi screen.

Mladen Vranjican
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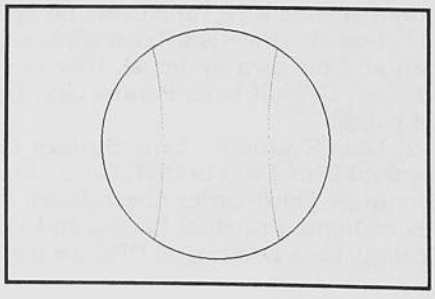
OPD = 0.25 waves
f/13.3
Grating position = -.3
Grating = 100 lines per inch



What's New? Products of Special Interest to Telescope Makers

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8087 and CGA required
CRT only $199; HPGL plotters $249

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For many years my one desire in optics was a computer program that would enable me to check optical designs for performance and also allow me to design an optical system from scratch or optimize one -- but the software from as little as a decade ago was either for minicomputers or pocket calculators. Faced with a house full of telescopes when I retired, I decided to sell some and use the money to secure a powerful (and compatible!) computer.

Once in possession of my clone, another problem surfaced: the high cost of professional-type design programs. I found that many low-cost offerings were inadequate for what I wished, and none had an operating manual that gave adequate instructions and in some cases even assumed that the operator was familiar with lens design and computer programs. On the other hand, powerful programs cost as much as $5,000, which couldn't be justified.

Then at an RTMC meeting several years ago a flyer was distributed announcing that a lens design program called Optical Systems Design Program (OSDP) was being made available for the IBM-PC, XT, AT, and close compatibles and would cost only $199.

Is the program satisfactory for amateur and professional use? I took the manual into my old company (McDonnell Douglas) and we compared it with what it had been using. It appears that OSDP is similar in power to the professional OLSO in many respects. My former teammates were quite impressed by both its capabilities and cost.

The manual is also quite comprehensive. Six sections cover the following functions and operations:

1. Lens Parameters. Load a library of examples (one can add his own systems), New Lens or Update information, Default Lens Parameters, Lens Specifications. 24 pages.

2. Lens Evaluate. Lens Surface Parameters to CRT, General Lens Data to CRT, Lens Data Printout; Paraxial Raytrace, Third-Order Aberrations, Paraxial Chromatic Aberrations, Principal Planes and Focal Lengths, Lens Scaling, Lens Drawing to CRT. 18 pages.

This section of the program uses a paraxial raytrace to print results on the CRT or printer. It does third-order aberrations, paraxial chromatic aberrations, principle planes, focal lengths, scaling the lens, and drawing the lens to the CRT with ray bundles to show light as it passes through various sections of the assembly.

3. Lens Raytrace. Single Skew Raytrace, Sagittal (XFAN) of Rays, Tangential (YFAN) of Rays. 7 pages.

In this section one can trace a single skew ray and trace sagittal (XFAN) or tangential (YFAN) of rays. These plots are important in determining how well a given system will perform.

4. CRT Graphics. Trace Spot Rays, Spot Diagrams, RMS Best Focus and Spot Centroids, Knife-Edge Energy Distribution, Radial Energy Distribution, Ray Fans, Field Aberrations (Distortion and S*T), Axial Color, Lateral Color. 14 pages.

This section lets one put CRT-graphic spot diagrams for various locations in the focal plane and finds the RMS best focus and spot centroid locations. It also has the knife-edge energy distribution and radial energy distribution plots, but the amateur will not have much application until he has a through understanding of how to apply these plots.

Ray fans, which are plots of the focal plane differences across the aperture, can be put on the CRT, or they can be printed out on a dot-matrix printer. Plots of field aberrations such as distortion and sagittal and tangential differences can also be displayed along with axial color and lateral color.

5. Plotter Graphics. This section was still in the works when I got the program, but I understand it is now available. It will drive HPGL plotters to display program output.

6. Lens Auto Design: Variables. Input and Output, Operands: Input and Output; Numbered Iterations; Continuous Iterations; Scale Change Vector; Display Current Change Vector; Damping Factor, Derivative Increment; Restore Variables; Merit Function. 30 pages.

In addition, there are examples covering inputting a new lens into OSDP, scaling a lens using Lens Evaluate, tracing an optical system containing tilts like a Tri-Schiefspiegler, and optimizing a lens using Auto Design. An appendix reviews the sign convention used to input data in the program.

One of the most useful parts of the first section is the built-in defaults that enable one, after entering lens data and specifications, to apply inputs for test parameters that are already in the program. Until one learns how to use the program, this feature is valuable in obtaining design information and aberrations of an optical system. Even after I became familiar with the program operation, I found it expedient to use the default figures especially for quick looks at designs.

The lens library has a number of standard optical systems that one can call into the program and examine and study and experiment on, among which are a Newtonian, catadioptric, and Schmidt camera. One can also add his own optical specifications to the library for later recall.

I recommend the amateur approach of the section on auto design with care. First work with the rest of the program in various designs, making tests and variations in specifications to learn how the optical system reacts to changes. A very thorough understanding of optics and lens aberrations and the reaction between various ones is needed to make use of this feature.

How well does this program compare with the more expensive ones the professional uses? I had several friends who are lens designers compare ray traces of a recent design in *TM* using this program and OSLO -- with almost the same results. From what I have been able to determine and from these checks, I am pleased with the results and quality of the OSDP program.

I found it fascinating to run spot diagrams for a large-aperture f/4.5 Newtonian, a Ritchey-Chretien, and Schmidt camera and view the results. The Newtonian had an excellent axial image, as expected, but the edge coma at the edge of a 2-inch ocular was 0.0059 inches. The Ritchey-Chretien, which has no coma, showed astigmatism with a size of 0.003 inches. The Schmidt had a star image size of 0.002 inches.

In the time I've worked with the OSDP program, I have become convinced that it is excellent and easy to use and has one of the best manuals I have yet found for such programs. I recommend it with no reservations.

-- *Robert E. Cox*

Optical Glass
by T. Izumitani
published by Kyoritsu Shuppan Company, Ltd.
translated by Berkeley Scientific Translation Service

Technical Information Department
Lawrence Livermore National Laboratory
University of California
Livermore, CA 94550
$40.00

My library has several books on glass, its composition and working, and one is *Optical Production Technology* by D. F. Horne, published in 1972. It was most enlightening to compare the two approaches to many of the similar sections in these books, but each has its own approach to many phases of glass working and how to make use of the results of the research.

The author of this book, Dr. Izumitani, works at the Osaka Industrial and Technical Experimental Institute in Japan and has published numerous papers on the properties of glass and its working. The book represents a summary of his more than thirty years of research and study of the subject. He mentions by way of defining the book that it could have been titled "My View of Optical Glass."

Optical Glass has five chapters. Their headings are What is Glass, Compositions and Physical Properties of Optical Glass, How are Optical Glasses Produced, Cold Working of Optical Glass, and New Glasses.

The first two chapters are filled with chemical and physical information and many formulae and diagrams of atomic and molecular arrangements of the elements that make up a glass structure. Unless one is a physics major intending to make the field of glass a life work or involved in this field, these formulae can be ignored; just the text and diagrams need be applied when you read these chapters.

There is one section of interest in chapter two, section 2.2.3, on the chemical curability of glasses. I believe many amateurs will find this an eye opener because it relates to the relationship of water to a glass surface: the cause of dimming or staining of a surface and how an understanding can help many workers minimize these problems.

Chapter 3 covers how striae and bubbles are formed and how can they be prevented. Annealing and the changes it produces in a glass melt are also discussed.

The most valuable chapter is the fourth, on the cold working optical glasses. Its six sections contain a wealth of information relating to polishing different types of glass and the materials used to do it. There are three theories at the beginning of this chapter on the mechanism of polishing glass. These are: 1) the mechanical microscopic cutting theory of Rayleigh, in which the polishing of glass is accomplished by mechanical fracture and removal on the order of molecules; 2) the flow theory of Beilby, in which the surface of the glass is locally and instantaneously heated by friction with the polishing agent (as a result the protruding parts of the surface flow into the valley areas); and 3) the chemical reaction proposed by Preston and then by Grebenschchikov, that a silica gel layer is formed on the surface of the glass by a reaction with water and that this gel layer is removed by the polishing agent.

Dr. Izumitani's research conforms to the third theory, but he leaves the door open with the suggestion that perhaps all three mechanisms contribute to the polishing action.

It is important to note that Dr. Izumitani discussed the cold working of optical surfaces. It is well known that with a high-speed "hot" polish, glass does flow over the surface covering up pits or fractures caused by grinding. Many amateurs tried to use twin-polished parallel plate glass back in the 1960s to make windows and corrector plates. This glass had been worked with large high speed polishers on both surfaces to produce a fairly flat and parallel window glass. When they tried to polish the surface, they were dumbfounded to find the polished surface greyed with pits from fine grinding. This is a poor situation for a fine optical surface, because even though the pits are not on the surface, they do form a fine series of air bubbles under the flowed glass and still scatter light as it passes through.

To some it may come as a revelation that the material used most often to grind and polish—water—attacks surface of glass. Water forms a hydrated layer that a grinding and polishing action removes in working the surface. However, the study made in this book used an electron microscope to examine the surfaces for defects; in regular optical shop the use of a bright light and hand magnifier will not reveal the defects mentioned.

This is a specialized technical book. For an amateur who works out of his basement and makes telescopes for his own pleasure, it contains little to aid him in his work. There are some interesting sections on laps and polishing compounds that might help, but then much of the research used machines with a pressure and stroke rate one doesn't find in hand work. It is difficult to suggest that this book at $40 should be in the hands of every telescope maker.

However, if one is planning a career in glass manufacture or optical shop fabrication, there are many interesting ideas to be found here. For those in optical shops this book would be a useful source of information on working glass, cleaning and protecting lenses, and coating optical surfaces.

-- *Robert E. Cox*

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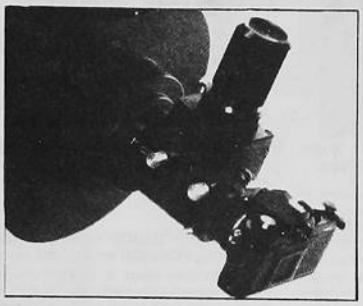

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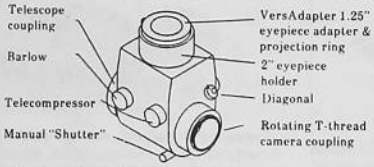

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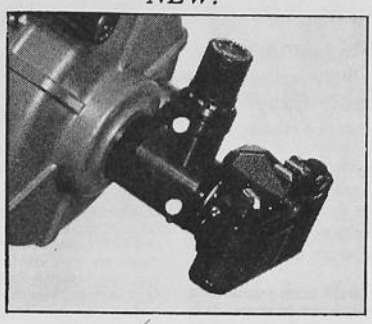

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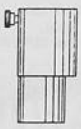

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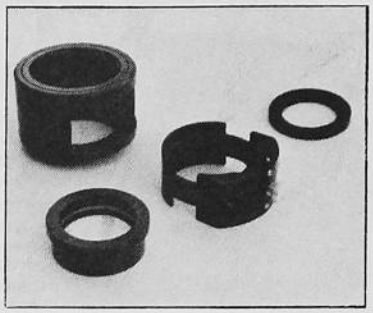

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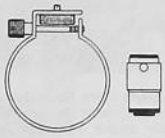

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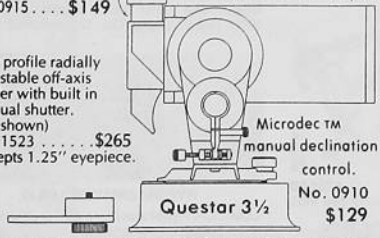

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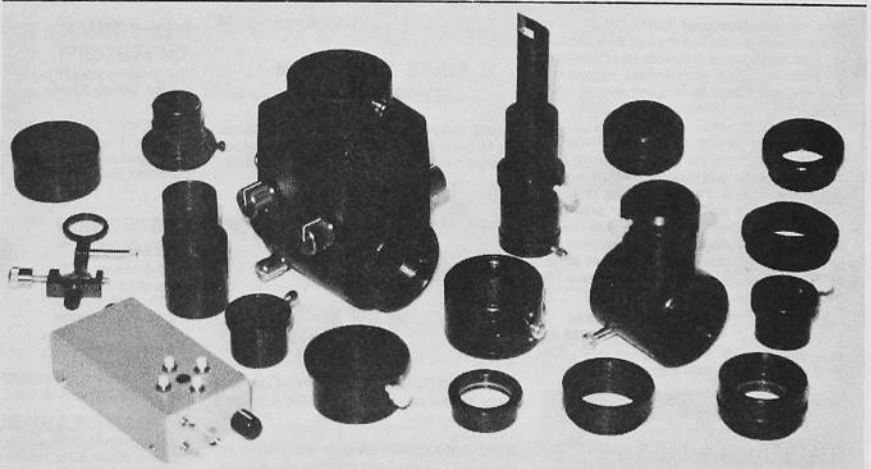

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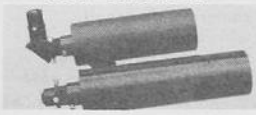
LUMICON Sky Vector™ (state scope) **$498**
Sky Vector™ Kit (you supply hardware) **$469**
Pair digital shaft encoders (for 2nd scope) **$135**

LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers perfer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F = 300mm coated achromat. The deluxe SUPER-FINDER uses an 80mm, F = 500mm air spaced achromat.

1¼" 50mm Finderscope **$59.50**, right-angle **$89.50**
1¼" straight-thru 80mm SUPER-FINDER **$169**
1¼" right-angle version, w/star diagonal **$195**
2" right-angle version, non-rotating focuser **$199**
1¼" Deluxe right-angle Super-Finder **$279**
2" Deluxe right-angle Super-Finder **$309**
25mm Cross-hair 1¼" eyepiece (12X) **$29**
1¼" Star Diag. . . **$32**, 2" Star Diag., silver, . . **$145**
1¼" Amici Prism diag. for correct left-right views **$59.50**

COMA CORRECTOR LENS

Coma 1 inch off-axis (17½" f/4.5)

Same Field with LUMICON coma corrector lens; note smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener
2" lens **$285.00**
Extension tube for viewing **$26**
2" Easy-Guider™ (state camera) . . **$169.50**

LUMICON®
2111 Research Drive #5T Livermore CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add $8 ($20 for HYPER-KITS)
California Residents add 6% tax.
Prices subject to change w/o notice.

NEW! ENCHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 3.1" enhanced silver diagonal mirrors & 2" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$29.95** 1.52" **$34.50** 1.83" **$39.50**
2.14" **$49.50** 2.60" **$65.00** 3.10" **$89.50**
4.25" **$149.50**

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.
1¼" (1.32" mirror) **$89.50**
2" (1.83" mirror)(see photo above) . . **$145.00**

OXYGEN-III FILTER

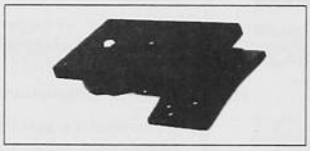
Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90% for both O-III lines at 496nm and 501nm.

Filter Type	1¼"	48mm
Lumicon Oxygen-III	**$99.50**	**$199.50**
Lumicon UHC	**$99.50**	**$199.50**
Lumicon Deep-Sky	**$79.50**	**$119.50**
Set UHC and Oxygen-III .	**$190.00**	**$380.00**

NOTE: The Oxygen-III Filter is not a substitute, but a compliment to the UHC Filter. **1 year guarantee:** You must see nebulae with the O-III filter that are **invisible** without a filter.

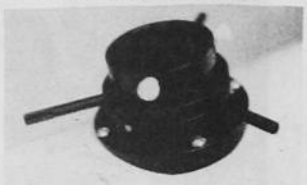
NEW ADJUSTABLE PIGGYBACK MOUNT



LUMICON has just designed a new adjustable piggyback mount ideal for all telescopes of 8-14" aperture. It has **both** vertical and sideways adjustment to allow optical alignment. It was designed to allow mounting of the LUMICON SUPER-FINDER on C-8, C-14, etc., but is ideal for any telephoto lenses or small telescopes.

Deluxe Piggyback Mount $45.00
(State Telescope Type)
LUMICON 12x80mm SUPER-FINDER . $170

NEW! LOW PROFILE HELICAL FOCUSERS



LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a 6" telescope.
LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.
Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD, SUPER-FINDER base plate.
LUMICON 1¼" Helical Focuser $49.50
LUMICON 2" Helical Focuser $59.50
LUMICON Non-rotating Helical Focuser $79.50
3 handles (see photo) for non-rotat. focuser **$12.95**
2"/1¼" adapter w/48mm filter threads . . **$20.00**
2" LUMICON EASY-GUIDER $169.50

PROTECTIVE DUST COVERS

Protective plugs (left), vinyl dust covers.
Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼" O.D. plug, seals focuser . . . . . **4/$2**
2" O.D. plug . **2/$2**
1¼", 1⅜" . . . . **3/$2**
1½" . . . . . **2/$2**
2" . . . . . **2/$2**
3½", 4½" **$5**
5½" **$6**
3½" O.D. plug **$1.50**
7½" **$8**
9½", 10.4"* **$12**
12½", 12⅞"* . . **$15**
16"* **$20**
19" (DS-16) . . . **$27**
*Fits Odyssey

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FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

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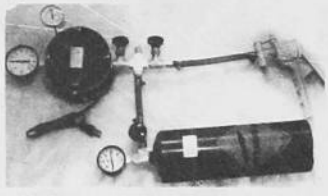
MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295.00**



MODEL 600 HYPER-KIT (See Photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350.00**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller **$595.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$280.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms of bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent #4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$169.50**
3X Relay Diagonal (see photo) **$79.50**
Illuminated reticle eyepiece system . . **$79.50**
Guider for Hasselblad **$350**, Mamiya 645 **$159**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation —3X shorter exposures! **Superb rich field viewing, too!**
CASSEGRAIN EASY-GUIDER **$225.00**
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GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) . . . . . **add $99.95**
Adapter for Hasselblad adapter **$195,** Mamiya 645, **$96**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$79.50**
Lumicon 12mm eyepiece system has adjustable L.E.D. illumination, dual crosslines, battery pack.

2. Cable release for long exposures . . **$9.95**

3. **LUMICON Quartz Drive Corrector . $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
Declination motor (state telescope) . . $70
NEW Deluxe Digital Qtz. Drive Correc. **$298**

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SR3200, fastest of all, color neg	24	**$13.95**
Konica SR400, fine gr. color neg	12	**$10.95**
3M 1000, fastest slide film	20	**$12.95**
Fujichrome RD100, fine gr. slide	24	**$12.95**
5072, color slides from negs	36	**$6.95**
D-19 B&W Developer	1 gal.	**$6.95**

~ Vintage training films on tape ~

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TAPE A

1 ROUGH GRINDING, 25:30
2 ROUGH GRINDING BY PIN BAR, 19:00
3 PITCH BUTTONING & BLOCKING — SPHERICAL LENS, 29:15
4 FINE GRINDING, 13:55

****

TAPE B

5 POLISHING, 27:20
6 CENTERING, EDGE GRINDING & BEVELING, 26:15
7 MEASUREMENT WITH LIGHT WAVES, 15:00
8 ROUGH GRINDING W/CURVATURE GENERATOR, 14:50
9 ROUGH GRINDING W/VERTICAL SURFACE GRINDER, 25:50

****

TAPE C

10 ROUGH GRINDING — FLAT SURFACES, 27:15
11 FINE GRINDING & POLISHING, 31:30
12 BEVELING, GROOVING & ROUNDING, 30:00
13 OPTICAL INSPECTION METHODS, PRT. 1, 26:00

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TAPE D

14 OPTICAL INSPECTION METHODS, PRT. 2, 20:00
15 PRODUCTION METHODS, 27:15
16 INTRODUCTION TO OPTICS, 16:45

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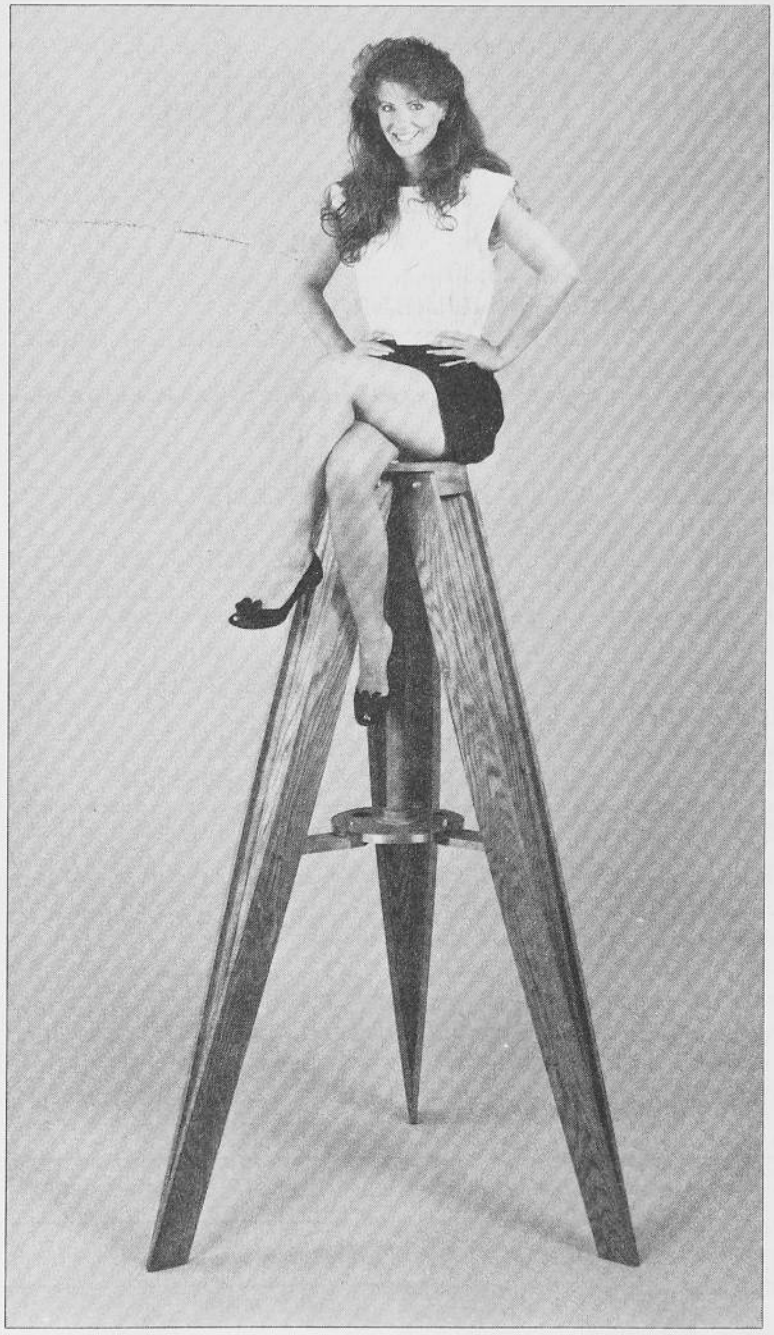

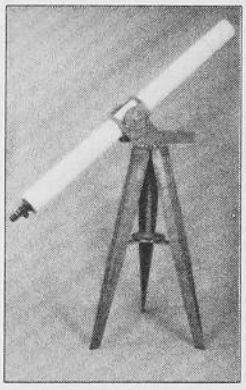

The Observer
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Based on a design by Richard Berry, this mounting is made to support long focal length high resolution refractors. A perfect companion for your Christen F/12, Brandt F/13.3 or even a Jaegers or Clavé 6" F/15. Rock solid, vibration free and silky smooth, it moves at a fingers touch. For those of you who enjoy just observing without the hassle of equitorial set-ups and power requirements, this mounting is made for you. Our deluxe version pictured above, is assembled from solid oak hardwoods, oak plywoods and oak veneers. All the joints are clamped and glued, all the hardware and fittings are solid brass. This is truly an archival mounting designed and built to last a lifetime and longer. We can also build a mount to your requirements or if you wish the entire instrument using Christen, Brandt, Jaegers or Clavé optics. We have less expensive and smaller versions as well as mountings made of ash, cherry, pine or maple. Allow 90 days for delivery. *Write for our brochure and full color photo of our deluxe version with a 6" F/15 tube assy.*

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The 4.25" size is the 2-mirror design by A. Kutter; the larger sizes are the 3-mirror design by R. Buchroeder.

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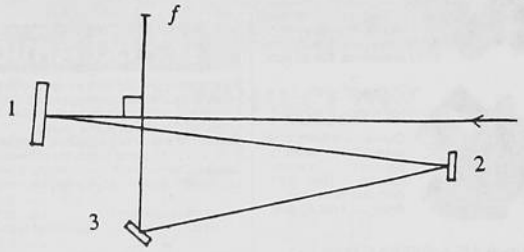
12.50" F/20...$2995.00
Complete Tube and Fork assemblies available.



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König Eyepieces — With their wide angle and pinpoint definition, these truly are the "king" of wide field eyepieces. The perfect match for all those large Dobsonians now available. All are multi-coated and threaded for our special wide-aperture photo-visual filters. 1¼" O.D.

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32mm ..... $79.95 ppd.

Astro Film

University Optics has been licensed to perform the gas hypersensitization of photographic film using the procedures defined under U.S. Patent 3,984,249. Our 25 years experience in astronomy and professional photography assures you a quality product. Films listed are 35mm unless noted.

Film Type	Exposure	Price
2415, ultra-fine grain B&W	36	$10.95 ppd.
3M 1000 (sensitized)	16	$12.95 ppd.
Sakura 3200	24	$13.95 ppd.
Sakura 1600, color negative	24	$11.95 ppd.
3M 1000 (unsensitized)	20	$ 7.50 ppd.

All film comes packed with dust-free packages of a drying agent. **2 or more rolls, 10% discount.**

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We carry some of the finest quality giant 2" O.D. oculars in the country. Black aluminum cells with chrome plated brass barrels. All are threaded for 48mm filters. Try our 55mm Plössl in combination with our 2" O.D. star diagonal for true wide angle views of the heavens.

32mm Konig-2. Multi-coated, wide field design. Price ..... $119.95 ppd.
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Tired of reversed and confused images when looking through your telescope? Give our quality Amici prisms a try!
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80mm f/6.6 REFRACTOR KIT
An exceptional quality 500mm air-spaced objective is the heart of this easy to assemble kit. All metal parts with giant 2" focusing mount .....
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Camera quality visual and photographic accessories for your Celestron and Meade Series 1000 and 2000 telescopes.
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Off-axis guider body only ..... $68.95 ppd.

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A new high-tech 8×50 viewfinder from University Optics! Fully illuminated with a precision Polaris alignment scale to help you get perfect alignment everytime under any conditions. Crosshairs in center of field as well as unique Polaris scale are illuminated with self-contained LED. No external wires. Large 1¼" size diagonal and eyepiece mechanism assures wide field of view. An advanced mounting bracket with 6 special screws will not mar the fine finish. Available in black for Celestron 8 and other telescopes and dark blue for Meade telescope line. ..... $139.95 ppd.

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11×80 Amici

It's a fantastic viewfinder! It's a versatile rich-field telescope! It's a compact spotting scope for nature study! We started with an 80 mm fully coated achromatic objective. We added a **fine quality 1¼" rack and pinion, 30 mm 1¼" crosshair eyepiece, and a 1¼" Amici diagonal prism for correctly oriented images!** Complete with tripod mounting block. Beautiful midnight black finish. Perfect for comet hunting.
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25×100 mm

Ultra-Giants! With their 4" objective lenses, these binoculars are the ultimate "light bucket" for deep-sky observing. They almost equal the performance of battleship binoculars, but at a fraction of the weight and cost. Multi-coated optics and oversize prisms. Complete with tripod adapter and carrying case ..... $575.00 ppd.

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MARK-5 Visual — An extremely high contrast filter for visual use only. For areas of extreme light pollution. Gives remarkable results on planetary and emission nebulae. Very narrow bandpass. For all 1¼" eyepieces. Premium grade ..... $59.95 ppd.

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A Major Advancement in Illuminated Eyepieces!

No more tangled wires! This 12.5mm 1¼" O.D. illuminated orthoscopic eyepiece has every important feature built right in. Focusable etched glass double crosshair. With its LED illumination, brightness control, and on-off switch right at your fingertips, this is an absolute must for serious astrophotographers.
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University has finally broken the price barrier on top quality Japanese Plössl eyepieces. Sure you can pay a lot more, but can you really tell the difference? True 4-element Plössl design with multi-coating.
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This is the eyepiece many of you have read about that corrects for coma in fast Newtonian mirrors. Our first offering is in 28mm fitting 2" and 1¼" mounts. Introductory price ..... $195.00 ppd.

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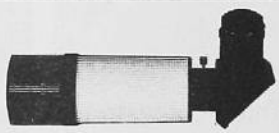

This all new University 8x50 viewfinder uses standard 1¼" eyepieces. The cell, tube, and eyepiece holder are metal for years of service. Don't confuse this unit with those made mostly of plastic! Comes with 1¼" star diagonal, and 1¼" wide-field Kellner with crosshair. Fully-coated achromatic 50mm objective lens. Mounting bracket is extra. Choice of black or white finish.

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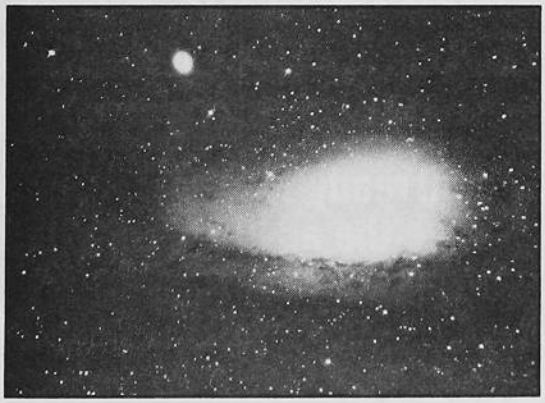
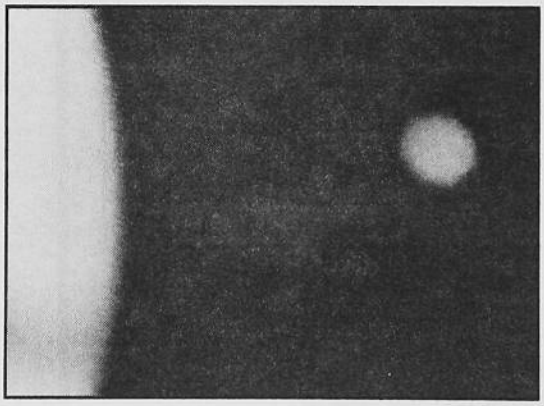
ABOVE: This 16-inch f/5-f/25 Newtonian/Cassegrain can quickly change from a wide field Newtonian into a high resolution planetary instrument. **BELOW LEFT:** This photograph is a 90 minute exposure of M-31 & M-32 at the f/5 focus. **BELOW RIGHT:** Jupiter and Io was taken on a night of perfect seeing with the f/25 (10160mm FL) focus, duplicated 35x for a 355,000mm EFL!





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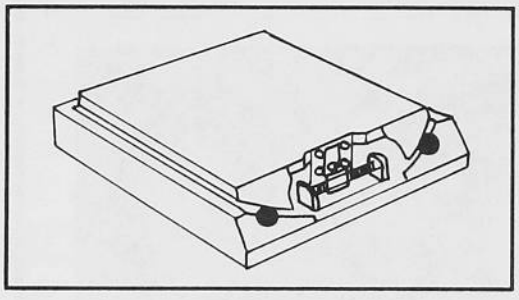

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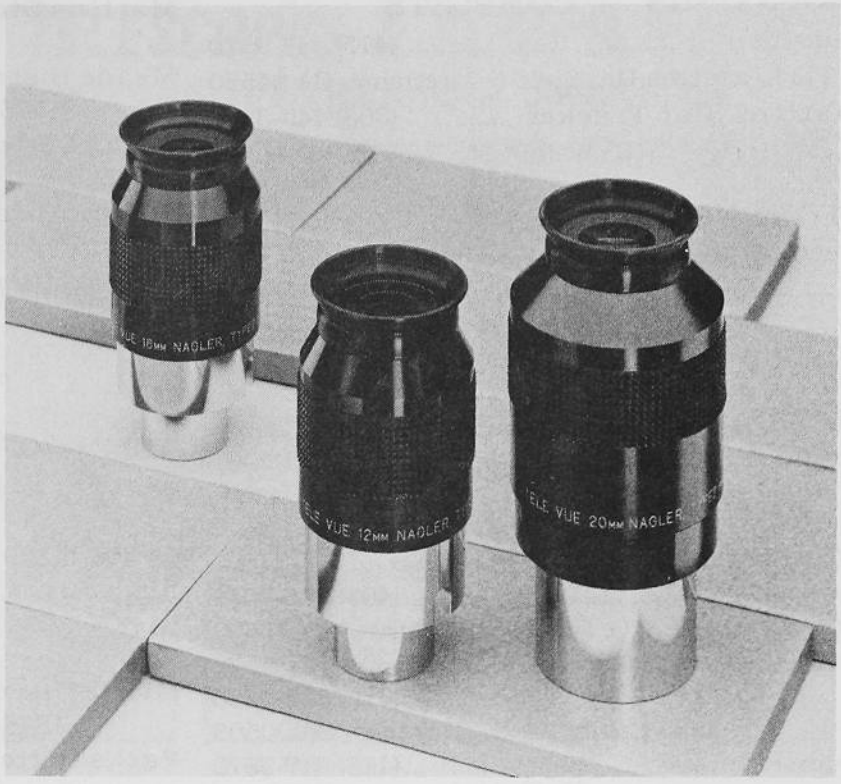
NAGLER TYPE 2 82° FIELD EYEPIECES



These new 8-element designs extend the Nagler concept to impressive new performance levels, while retaining the basic advances of the original Naglers:
—82° apparent field
—Full field correction
—Fast aperture correction

New Features Include:

First, three new focal lengths, 12mm, 16mm, and 20mm extend the concept to unprecedented wide viewing fields.

Second, full exit pupil correction permits comfortable night and day use.

Third, fold-down rubber eyeguards are included for maximum comfort and dark adaptation.

Fourth, relatively lightweight and moderately sized, they also have knurled rubber grip rings for easier handling.

Design Goals

The basic Nagler series has already achieved image correction 10 times better than previous wide angle eyepieces (study in "Telescope Making" titled "The Nagler 13, a Remarkable Telescope Eyepiece"). We felt that trying to extend the apparent field or image correction levels beyond that of the original Nagler series would NOT yield significant practical gains, but that extending the focal lengths WOULD offer enormous potential for spectacular low power, wide-angle viewing. After all, Tele Vue Wide-Field eyepieces have already proved the value of low power 65° viewing with important improvements in image sharpness.

What were the barriers to simply scaling up the original Nagler designs to longer focal lengths?

Two practical limits had to be overcome:

1) Substantial physical size, weight, and cost increases would be impractical.
2) Scaling up exit-pupil aberrations would be unacceptable in our judgement. Although the original Nagler eyepieces provide extremely sharp IMAGES, exit-pupil aberrations require a large (nighttime) eye pupil opening to encompass the full field. For this reason, daytime viewing with the 13mm Nagler is not recommended. Eye positioning is just too sensitive with this design to consider focal lengths longer than 13mm. The 9mm and shorter Naglers don't show this sensitivity.

Nagler Type 2: The design breakthrough!

The design experience gained in developing the patented Plössl, Wide-Field, and Nagler eyepieces resulted in an even more advanced concept: — 8-element, 82° field designs (pat. pend.) with full correction of exit-pupil aberrations that permit the most comfortable viewing ever — night or day! Each model is a unique design, with a tailored eye relief like the 9mm Nagler, yet surprisingly compact, lightweight, and affordable. Extensive computer-aided design efforts and the use of new glass types retained the traditional superb full-field and fast-aperture sharpness. Of course, our pioneering lens edge-blackening, and multi-coating are included for maximum contrast.

A further important contribution to viewing comfort and effectiveness is a fold-down rubber eyeguard. This eliminates stray light and enhances dark adaptation to aid in detecting faint, delicate nebulosity and comets. The eyeguard is a delight on cold nights too.

20mm Nagler Type 2: This has the largest true field in the series, even larger than our 32mm Plössl. Yet this eyepiece, (strictly for 2 inch focusers) is comparable in size and weight to a 13mm Nagler. There's nothing like this 20mm for viewing large deep-sky open clusters, galaxies and nebulae. It gives a 4.5mm exit-pupil with f/4.5 telescopes. Daytime viewing is also simply stunning!

16mm Nagler Type 2: Offers far more true field than the 13mm Nagler, yet is similar to the 11mm in size! Great day or night performance with any telescope.

12mm Nagler Type 2: As superb as the 16mm, but with higher magnification. An excellent alternate to the 13mm or 11mm Nagler, which are preferable where the longer eye relief is of benefit to people who MUST wear eyeglasses to correct severe astigmatism.

The 16mm and 12mm TYPE 2 NAGLERS also work beautifully with Tele Vue Barlows. They both have 1¼" barrels that are parfocal with our other eyepieces and can also be used with 2" focusers.

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Telescope	F.L. Inches	21.6	30	40	50	60	80	110
	F.L. mm	550	762	1016	1270	1524	2032	2794
Barrel Diameter	Type 2 Nagler Eyepiece F.L.	Power						
2"	20mm	28x	38	51	64	76	102	140
		34	48	64	79	95	127	175
1¼"-2"	16mm	62 86	86 119	114 159	143 198	171 238	229 318	314 437
		46	64	85	106	127	169	233
1¼"-2"	12mm	83 115	114 159	152 212	190 265	229 317	305 423	419 582

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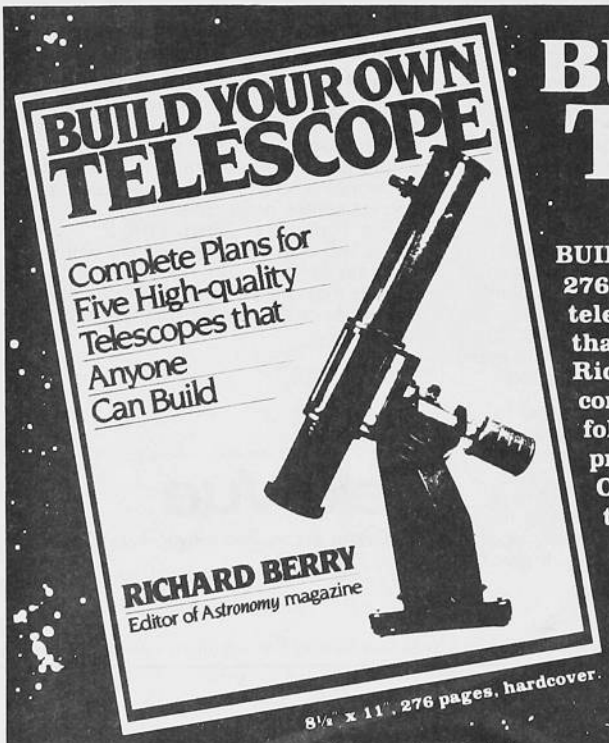

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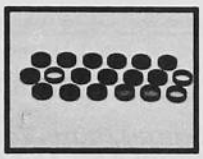

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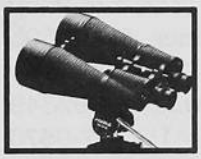

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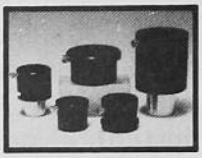

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15mm	1¼"	52°	Yes	130.00	69.00
20mm	1¼"	52°	Yes	140.00	79.00
25mm	1¼"	52°	Yes	140.00	79.00
30mm	1¼"	52°	Yes	180.00	89.00
35mm	1¼"	49°	No	200.00	89.00
3.8mm	1¼"	52°	Yes	240.00	129.00

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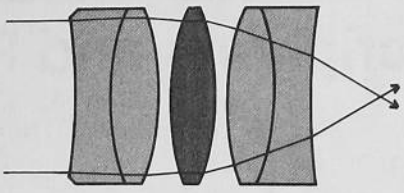

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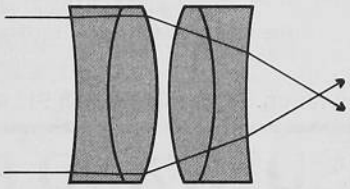

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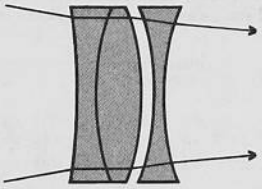

Meade Series 4000 Barlows: 3 elements, air-spaced, instead of the standard 2 non-air-spaced elements.

Series 4000 Eyepieces and Barlows

Super Plössls (5-elements)	APPARENT FIELD	BARREL DIA.	PARFOCAL
6.4mm	52°	1¼"	Yes
9.7mm	52°	1¼"	Yes
12.4mm	52°	1¼"	Yes
15mm	52°	1¼"	Yes
20mm	52°	1¼"	Yes
26mm	52°	1¼"	Yes
32mm	52°	1¼"	Yes
40mm	44°	1¼"	No
56mm	52°	2"	No
Super Wide Angles (6-elements)			
13.8mm	67°	1¼"	Yes
18mm	67°	1¼"	Yes
24.5mm	67°	1¼"	Yes
32mm	67°	2"	No
40mm	67°	2"	No
Ultra Wide Angles (8-elements)			
4.7mm	84°	1¼"	Yes
6.7mm	84°	1¼"	Yes
8.8mm	84°	1¼" & 2"	Yes
14mm	84°	1¼" & 2"	No
Barlow Lenses (3-elements, air-spaced)			
#140 2X Telenegative Amplifier		1¼"	Yes
#142 2.8X Telenegative Amplifier		1¼"	Yes

Meade 2" Mirror Diagonal: For attachment to Schmidt-Cassegrain telescopes, the 2" Mirror Diagonal permits use of Series 4000 eyepieces with 2" barrels. The 1/10-wave-flat Pyrex mirror, manufactured at the Meade Costa Mesa optical facility, is multi-coated with enhanced aluminum for maximum reflectance. An adapter for 1¼" eyepieces is included.

Where To Buy: Meade Series 4000 eyepieces and Barlows are available from over 600 authorized Meade dealers in the U.S.A. and Canada. Call us toll-free (see below) for your nearest dealer.

Meade®: First in Eyepieces too.

Super Plössls: With 5 optical elements rather than the traditional 4, Meade Super Plössls provide a 40% improvement in corrections for chromatic aberration and edge-distortions over any other premium Plössls. Best for general observing at moderate cost, the Super Plössl eyepieces are perfect optical complements for the Series 4000 air-spaced Barlows, below. Try the 56mm on your 8" Schmidt-Cassegrain for an actual field of over 1.4° at 36X!

Super Wide Angles: These 6-element eyepieces, with their 67° fields, offer exquisite wide-angle images at low to medium powers, ideal for star fields, galaxies, and other deep-space phenomena. Focal lengths with 1¼" barrels yield extremely high-resolution, high-power lunar and planetary images when combined with one of the Series 4000 Barlows.

Ultra Wide Angles: The ultimate in modern eyepieces, Meade 8-element Ultra Wide Angles permit extreme image fidelity and sharpness over an amazing 84° apparent field: for moderate to high power applications, no other eyepieces come close. A magnificent optical match with Schmidt-Cassegrains and fast Newtonians.

Series 4000 Barlow Lenses: The most sophisticated Barlows ever developed for commercial telescopes, these 2X and 2.8X Telenegative Amplifiers include 3-element, air-spaced, multi-coated optics, unmatched in image resolution and color correction. Both models optically complement the Series 4000 eyepieces, while significantly enhancing the performance of other eyepieces as well.

Prices: Notwithstanding their performance standards and optical sophistication, Meade Series 4000 eyepieces and Barlows are priced very competitively with other premium oculars and Barlows.

Warranty: All Series 4000 systems are covered by the Meade Limited Lifetime Warranty—the most extensive in the industry. See the Meade catalog for details.

New 1986 Meade General Catalog 86-R: $3.00

Just-published, the new Meade 1986 General Catalog includes complete information on the full range of Meade astronomical products, along with a supplement on **"How To Choose Your Eyepieces."** Send $3.00 for your copy.

U.S. and Canada Dealer Locations & Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments **toll-free** from anywhere in the continental U.S.A., (except Calif.):

1-800-854-7485

From all other areas, including California, call direct: **(714) 556-2291**

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